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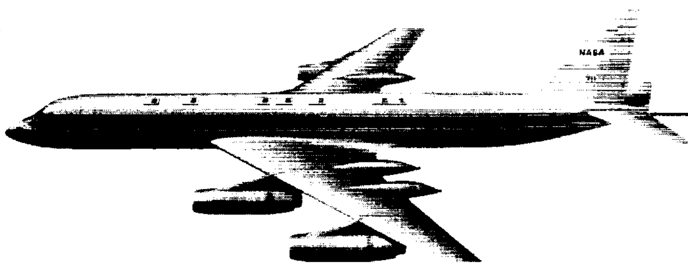

NASA CV-990 AIRBORNE LABORATORY
EXPERIMENTERS' HANDBOOK

Prepared by

STAFF, AIRBORNE SCIENCE OFFICE

(NASA-TM-108619) NASA CV-990 AIRBORNE LABORATORY: EXPERIMENTERS' HANDBOOK (NASA) 92 p

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Ames Research Center
Moffett Field, California 94035

NASA CV-990 AIRBORNE LABORATORY

EXPERIMENTERS' HANDBOOK

INTRODUCTION

In October 1964, NASA purchased a CV-990 to be modified and used for Space Sciences and Aeronautics research. The CV-990 is a Convair four-engine jet passenger transport with a range of about 3300 nautical miles, a practical operating ceiling of about 41,000 feet, and a useful payload of about 20,000 pounds. Special view ports, power supplies, and other general use facilities and instrumentation were installed. The aircraft was delivered to NASA-Ames in April 1965.

The aircraft is based at the Ames Research Center, Moffett Field, California. It is operated by Ames for individual or groups of scientists whose proposals are deemed suitable and are approved by NASA Headquarters, and it may be flown to other operating bases as required.

The purpose of this Handbook is to acquaint potential experimenters with the aircraft and its capabilities, to describe the established procedures for securing approval of missions, and to outline the requirements for equipment design and installation. As new aircraft modifications and procedural changes occur, replacement sheets will be mailed to recipients of the Handbook--hence, the loose-leaf format. A completely revised edition was issued in November 1970, rather than replacement sheets. Handbooks with pages dated Apr. 69 and before are obsolete.

Our most severe operational problem has been the failure of experimenters to design, stress-analyze, and construct their equipment in accordance with accepted aircraft standards. The reader's attention is called particularly to Section 5.6 of this Handbook.

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SECTION 1

PROPOSAL PROCEDURES

1.1 General Definition

The CV-990 research is broadly divided into aeronautics (A) and space sciences (S). In this definition, aeronautics includes all studies related to aircraft performance and systems (e.g., aerodynamics, inertial navigation), while space sciences includes those programs where the aircraft is used as an airborne platform for other research (e.g., astronomy, meteorology).

1.2 Submission of Proposals

Requests for CV-990 flight time must be submitted in the form of a Proposal to NASA Headquarters. Copies for "A" or "S" programs should be submitted as follows:

1.2.1 Proposals from all sources:

Three copies to:

<u>either</u> (A) Mr. J. A. Martin, Code RAD
<u>or</u> (S) Mr. M. Dubin, Code SG

National Aeronautics and Space Administration
Washington, D. C. 20546

<u>and</u>

two copies to:

(A,S) Dr. M. Bader
Airborne Science Office

NASA-Ames Research Center
Moffett Field, California 94035

1.2.2 Proposals from all U. S. sources other than NASA:

(A,S) Office of University Affairs
Code Y
National Aeronautics and Space Administration
Washington, D. C. 20546

Ten copies should be submitted to the above Office, in addition to the copies specified in paragraph 1.2.1.

1.2.3 Proposals from foreign sources:

(A,S) Office of International Affairs
Code I
National Aeronautics and Space Administration
Washington, D. C. 20546

Ten copies should be submitted to the above Office, in addition to those specified in paragraph 1.2.1.

1.3 Proposal Contents

Proposals should be as brief as possible, consistent with completeness—extraneous prose delays evaluation. The following items should be covered.

1.3.1 Technical

a) Scientific objectives: present state of knowledge, what can be gained from the use of the CV-990, interest or applications of results to science or engineering.

b) Techniques: approach, instrumentation and accuracy, data reduction.

c) Logistics: flight times, locations, profiles.

d) Equipment: size, weight, power, photographs, if possible, and desired location aboard aircraft.

e) Special needs: windows, stabilized platforms, temperature restrictions, ground equipment, etc.

1.3.2 Management

State the names, titles, and addresses of the principal and co-investigators. Brief resumes may be helpful in some cases. Organization and the functions of individuals should be given in cases where the proposal covers a coordinated program, e.g., several experiments from different organizational elements.

A cost proposal should be submitted (U.S. investigators only) if financial support from NASA is desired. This proposal should <u>not</u> include flight operations and logistics costs, as these are funded internally by NASA if the project is approved.

Details of what the Ames Research Center can furnish (at no cost) in terms of auxiliary equipment and support for experimenters' equipment installation aboard the aircraft can be found in subsequent Sections of this Handbook. In general, the experimenter is responsible for the design, stress analysis, construction, shipping, and installation of his equipment, while Ames provides a nominal amount of engineering advice, equipment such as fork lifts (with operators), and a nominal amount of installation manpower (mechanical and electrical technicians).

1.4 Proposal Review and Deadlines

Proposals are reviewed by the cognizant NASA Headquarters Program Office and by the Airborne Research Steering Committee. Broad scheduling is done by the Airborne Research Steering Committee when agreement is reached that the mission should be flown and assurance of funding is obtained from the Program Office. Detailed scheduling is done by the Ames Research Center.

The membership of the Airborne Research Steering Committee is as follows:

Mr. M. Dubin, Chairman, Code SG, NASA Hqrs.
Mr. J. A. Martin, Vice-Chairman, Code RAD, NASA Hqrs.
Mr. B. T. Nolan, Executive Manager, Code SRR, NASA Hqrs.
Dr. A. B. Park, Member, Code SRR, NASA Hqrs.
Dr. M. Bader, Member, Code SS, NASA-ARC

The addresses of the members are given in paragraph 1.2.1. The Committee meets approximately once every three months, but submission of proposals should not be tied to this schedule. A minimum lead time of six months prior to first use of the aircraft (normally this is equipment installation) is generally required; greater lead times are needed for large coordinated efforts (e.g., five to ten major experiments) and/or when the mission involves basing the aircraft away from Moffett Field.

SECTION 2

AIRCRAFT PERFORMANCE

2.1 Basic Aircraft Performance

The NASA Convair 990 (Fig. 2.1) is similar in appearance and performance to most other present-day jet transports. An unusual feature is the four wing-mounted anti-shock pods that reduce aerodynamic drag at high speeds and also serve as fuel tanks. The aircraft is of all metal construction with full cantilever wing and tail surfaces, and is powered by four General Electric CJ-805-23B aft-fan turbojet engines delivering a maximum thrust of 16,050 lb each. The following subsections summarize the aircraft performance.

2.1.1 At maximum takeoff gross weight (240,000 lb):

PAYLOAD (lb)	FUEL (lb)	RANGE (n.mi.)
21,000	100,000 (max.)	3,300
31,000	90,000	2,900
41,000 (max.)	80,000	2,500

The maximum takeoff gross weight may be reduced by such factors as runway length, slope, surface, and air temperature.

2.1.2 The airplane normally requires jet transport rated runways in excess of 6,000 ft (at sea level) when the takeoff weight is 200,000 lb . With a maximum takeoff weight of 240,000 lb, the runway length should be in excess of 9,000 ft.

2.1.3 Maximum altitude and time on station versus gross weight—based on standard atmospheric temperature.

GROSS WEIGHT (lb)	ALTITUDE (ft)	MAX. TIME AT MAX. ALTITUDE
230,000	33,000	$6^h\ 20^m$
215,000	35,000	$5^h\ 40^m$
195,000	37,000	$4^h\ 00^m$
175,000	40,000	$2^h\ 00^m$

A 14,000-lb payload is assumed. For every 1,000 lb difference, the time changes approximately 5.6^m. The time data assume that a landing field is available in the immediate vicinity at the end of the high-altitude period. Variations on these basic data are possible, primarily by using cruise-climb techniques.

2.1.4 Speed envelope, based on standard atmospheric temperature.

PRESSURE ALTITUDE (ft)	TRUE AIRSPEED (kt)		
	Minimum	Maximum	Window Covers Open
5,000	270	404	404
10,000	290	450	450
15,000	288	493	493
20,000	312	534	533
25,000	334	538	524
30,000	370	528	513
35,000	397	518	500
40,000	434	514	496

For approximate planning purposes, the normal cruise speed at the higher altitudes can be taken as 480 kt. (1 knot = 1 nautical mile per hour = 1 arcminute per hour.)

2.1.5 Turn radius and time to turn

For many types of experiments, it is desirable to fly over several closely spaced check points. However, since the CV-990 is a relatively high speed aircraft, the turn radius can become large. To aid experimenters in planning check points, the tables below list the turn radius and the time to turn 360° for several bank angles at three representative flight speeds.

	Bank Angle (deg)	Turn Radius (n.mi.)	Time to Turn (min)
300 kt:	15	4.9	6.2
	30	2.3	2.9
	45	1.3	1.7
	60	0.8	1.0
400 kt:	15	8.7	8.2
	30	4.0	3.8
	45	2.3	2.2
	60	1.3	1.3
500 kt:	15	13.6	10.2
	30	6.3	4.8
	45	3.6	2.7
	60	2.1	1.6

2.2 Frequency of Flights

Assuming a single flight crew, schedules should not exceed 8 flight hours per 24 hours, 30 flight hours per week, or 100 flight hours per month. These are also practical limitations for aircraft maintenance during normal working hours.

Additional manpower can usually be scheduled to accommodate greater flight frequencies, but this requires advance notice and entails additional expenses. The justification for heavy scheduling is always carefully scrutinized.

2.3 Cabin Pressure, Humidity, and Temperature

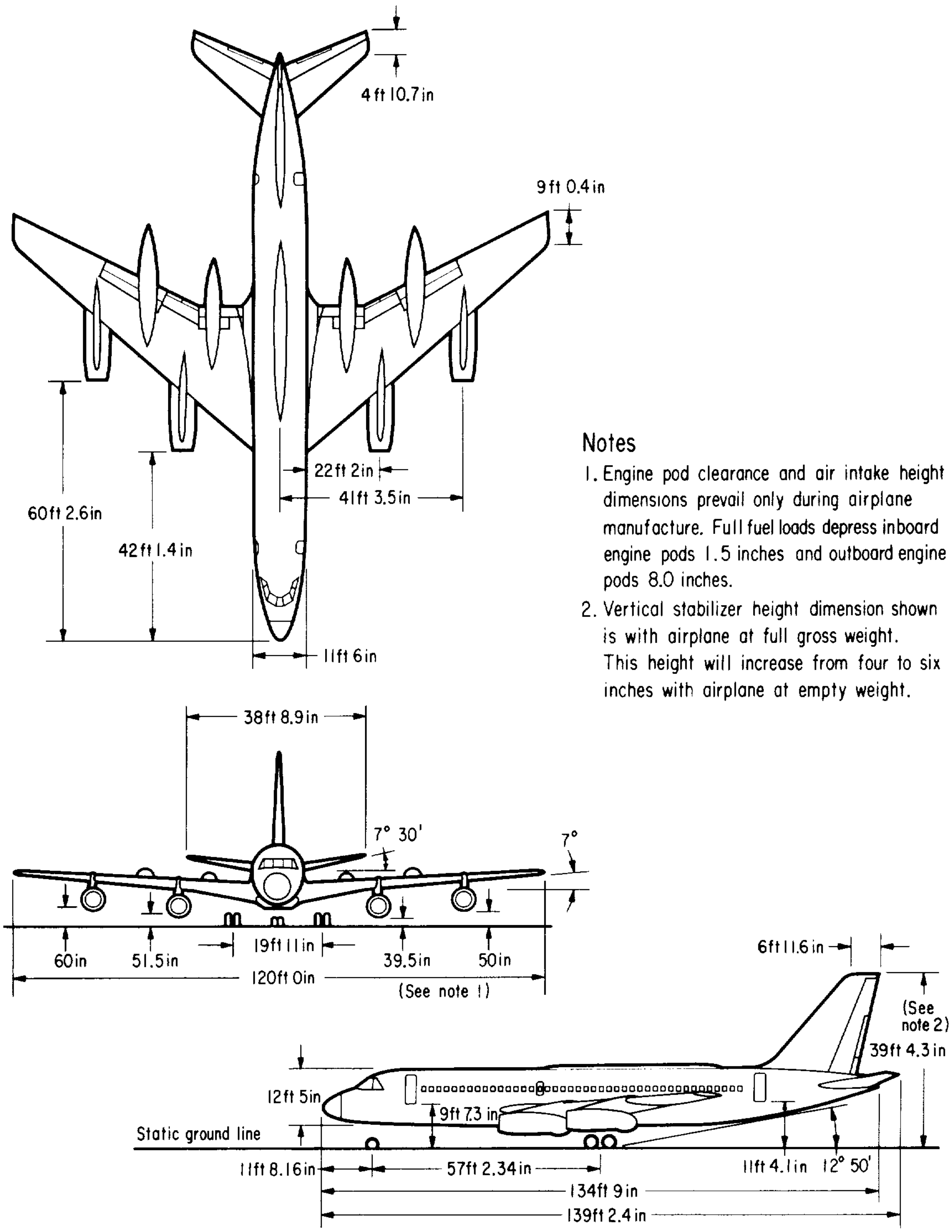
The cabin and the cargo and electronics compartments are normally pressurized to about 8,000 feet when the airplane is at 40,000 feet. The humidity in the cabin during flight nominally averages about 10% and the temperature is usually held between 65°F and 74°F. It is possible to hold the cabin temperature within ±2°F of its nominal desired value.

2.4 Aircraft Stability

A standard Sperry SP-30 autopilot controls the heading and altitude of the NASA CV-990. Nominally, the autopilot can limit aircraft excursions to within ±2° in pitch, roll, and yaw (in smooth air). However, with advance notice, this stability can be enhanced by tuning the autopilot for an anticipated airplane altitude, airspeed, and loading. The following are typical aircraft stability data with the tuned autopilot in operation at a pressure altitude of 38,000 ft, a true airspeed of 490 kt, and a gross weight of 180,000 lb:

Period (sec)	Roll (arcmin)	Pitch (arcmin)	Yaw (arcmin)
5	±12	±3	±6
100	±42	±6	±12

When records of aircraft stability are required, a wide-angle, rate-integrating gyroscope package is available for installation aboard the airplane (Fig. 2.2). The unit consists of three rate integrating gyroscopes and amplifier and power supply units. Outputs from the three gyroscopes and a time signal are recorded on a Visicorder strip-chart recorder.



Notes

1. Engine pod clearance and air intake height dimensions prevail only during airplane manufacture. Full fuel loads depress inboard engine pods 1.5 inches and outboard engine pods 8.0 inches.
2. Vertical stabilizer height dimension shown is with airplane at full gross weight. This height will increase from four to six inches with airplane at empty weight.

General view and overall dimensions of the CV-990.

Figure 2.1 (Nov. 70)

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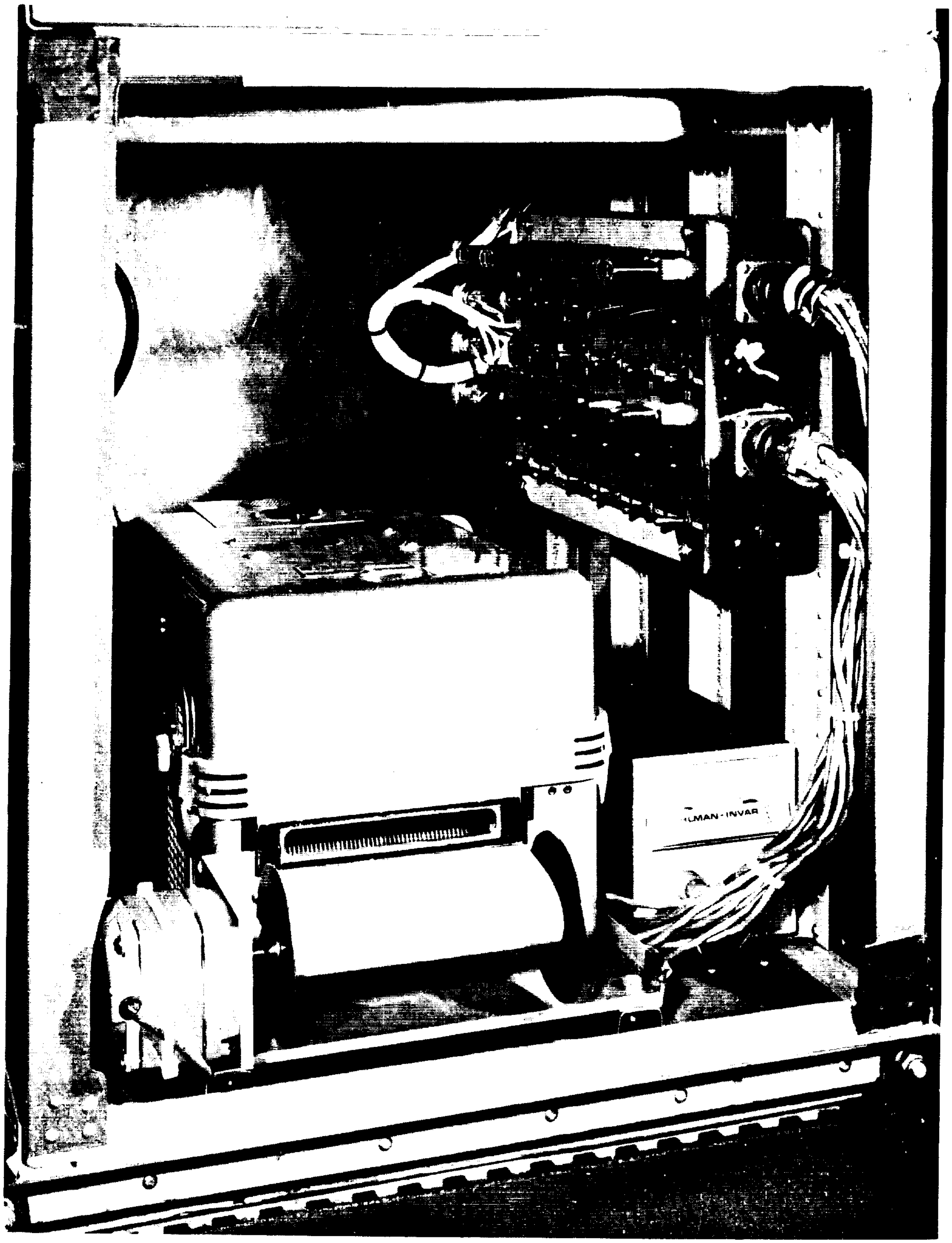


Aircraft motion monitoring package as installed aboard the aircraft.

Figure 2.2 (Nov. 70)

SECTION 3

RADIO COMMUNICATIONS AND NAVIGATION

3.1 Basic Equipment, Frequencies, and Operation

The airplane is equipped with a Bendix RDR 1B-2 weather radar and complete communications and navigation systems. Communication equipment consists of dual high frequency (HF), dual very high frequency (VHF), and ultra high frequency (UHF) radios. Navigation aids include an inertial navigation system (INS), dual VHF omnidirectional range (VOR), dual distance measuring equipment (DME), dual automatic direction finding (ADF), Loran A, Doppler radar, and a periscopic sextant.

3.1.1 Frequencies and interference

The frequency ranges of the various radio equipment are listed below. Experimenters are advised to engineer their equipment to prevent spurious response at these frequencies and to limit any output from their systems (e.g., telemetry) to 100 milliwatts.

Low frequency	200 to 1605 KHz
High frequency	3.0 to 30.0 MHz
Very high frequency	108.0 to 150.8 MHz
Ultra high frequency	225.0 to 500 MHz
Marker beacon	75.0 MHz
Loran A	1.8 to 2.0 MHz
Doppler radar	8800 MHz
Weather radar	9375 MHz
Radio altimeter	4200 to 4400 MHz

3.1.2 Location and operation

The weather radar, the INS, and all communication radios are set and controlled in the cockpit. It is possible to communicate through the cockpit radios from the navigator's console and from the Flight Director's console, located forward in the cabin (Figs. 3.1, 4.1).

Remote display units for the INS are located at the navigator's and Flight Director's consoles. The Doppler radar and Loran A controls and readouts are at the navigator's console which also contains a number of repeater instruments for certain standard cockpit readouts (Fig. 3.2). A camera has been installed to obtain, if required, a time lapse record of these readouts.

3.2 Navigation Accuracies

Some of the basic equipment is ineffective under certain conditions; for example, Loran is generally not available in the Southern hemisphere. The following are general guidelines on the accuracies obtainable with various devices individually, under average flight and weather conditions.

Celestial navigation with the periscopic sextant permits locating the aircraft within a 10-mile radius, with a real time delay of 10 to 20 minutes. Loran gives a 5-mile radius, and the DME about a 2-mile radius. The Doppler radar permits continuous track adherence and continuous readout of ground speed and drift; continuous wind and velocity data are hence available. The INS has an average position error of less than 2 miles per flight hour. It provides displays of present position (latitude and longitude), wind speed and direction, ground speed and track, and time and distance to the next way point. The INS also provides displays which permit adherence to indicated track within 1 mile.

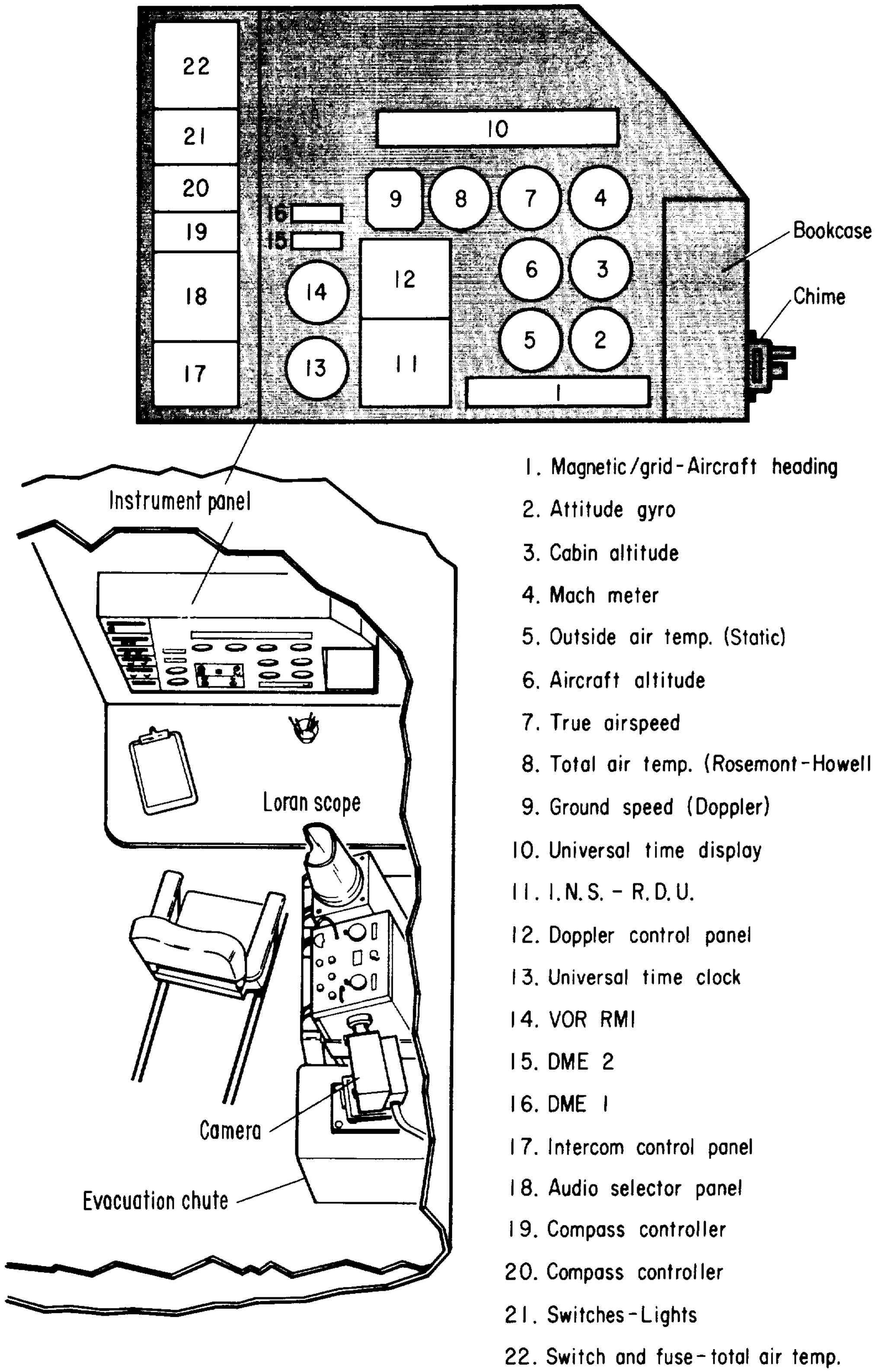
3.3 Navigation Planning and Programming

The Airborne Science Office (Ames Research Center) provides navigation planning and support to accommodate experimental requirements.

3.3.1 A special computer program is available to provide navigation data (times, headings, etc.) for the observation of any object for which right ascension and declination values are obtainable. The types of flight paths which can be calculated are constant bearing, constant turn rate, great circle, and loxodrome. The program provides object elevation data as a function of time for any of these flight paths. Constant aircraft speed and altitude are assumed. Wind corrections and other variations (e.g., change in speed) are computed on board by the navigator.

3.3.2 A more specialized computer program is available for solar eclipse observations. It provides:

a) the center line of the umbra path,
b) the extremities of the umbra path,
c) the shadow ellipse position and specifications at second and third contacts,
d) the wind-altered positions and times at second and third contacts,
e) the corrections for times of second and third contact resulting from errors in aircraft position.



Navigator's instrument panel.

Figure 3.2 (Nov. 70)

SECTION 4

CABIN DIMENSIONS AND MISCELLANEOUS FACILITIES

4.1 Dimensions of Cabin and Cargo Areas

Figures 4.1, 4.2, 4.3 give the general layout and dimensions of the cabin and cargo areas. The fuselage skin is an aluminum alloy (2024), generally 0.063 inch thick, and up to 0.100 inch thick in stress areas, such as in the vicinity of windows or other openings.

Most of the aerodynamic and other loads on the fuselage are carried by "belt frames", which are circular (Fig. 4.2) stretch-formed aluminum (7075) sections. They are typically 3.125 inches deep, with a 0.050 inch gauge. Except in stress areas, they are generally 19 inches apart. Belt frame numbers are distances in inches from the nose of the aircraft, which is counted as 100 (Fig. 4.1).

The floor in the cabin area is of 0.625-inch thick aluminum honeycomb panels attached to transverse floor beams (Fig. 4.4). Two seat support rails run longitudinally through the cabin and are flush with the honeycomb floor (Figs. 4.2, 4.4). A vinyl floor covering is installed over the honeycomb panels.

4.2 Fuselage Access and Cargo Doors

There are two main entrance doors located on the port side of the cabin and two utility doors on the starboard side (Figs. 4.1, 4.5).

On board access to the forward cargo compartment is through a 3x3-ft floor hatch located immediately aft of the Flight Director's desk (Fig. 4.1). Access from outside the airplane is through a 48x59-in. external hatch.

There are two external doors for the aft cargo bay. The forwardmost door is 59 inches longitudinally and 48 inches vertically; the aft door is 45 inches longitudinally and 34 inches vertically. There is a 19 x 21.25-inch access hatch from the cabin into the aft cargo bay ("G" on Fig. 4.1).

4.2.1 A section of the cabin floor over the aft cargo bay may be removed for loading large equipment into the cabin (Fig. 4.1). The size of container which may be loaded in this manner depends on how much it can be tilted. The loading procedure and size limits are illustrated in Figure 4.6. The hoist is rated for 2,000 lb, and the 3-inch clearance above the floor (Fig. 4.6, upper left) is intended for a dolly to move the load after the hoist system has taken it beyond the opening.

The handling of large and/or heavy items is difficult and time-consuming. Removing floor panels "F" (Fig. 4.1, 4.4) involves disconnecting aircraft control cables which run under the floor, and about half a day must be allowed for opening and again for closing the hatch. Maneuvering the load may require special ramps, slings, and jacks.

4.3 Miscellaneous Facilities

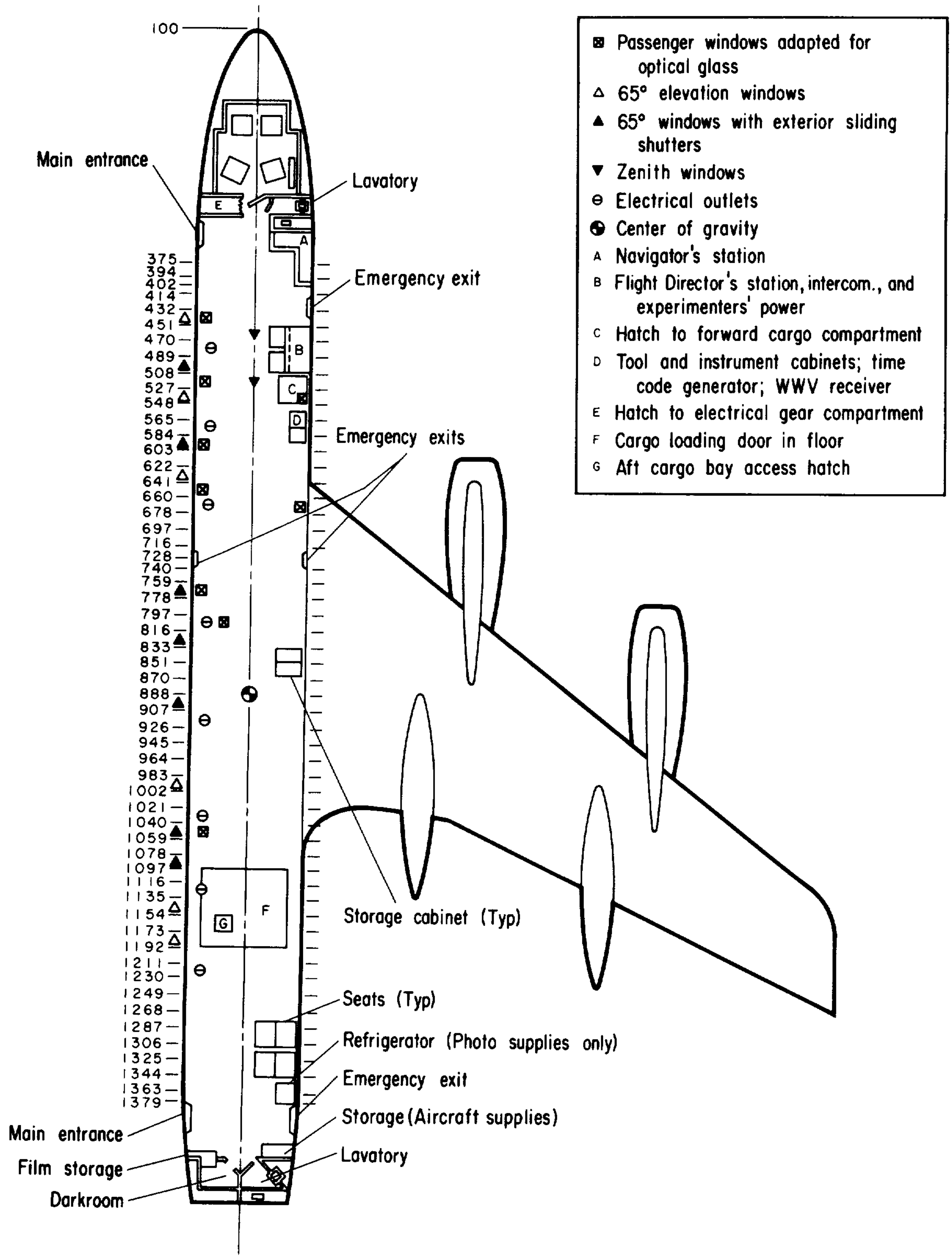
4.3.1 A command desk, or Flight Director's console (Figs. 3.1, 4.1, 4.7), is located just aft of the forward utility door on the starboard side. The console contains a two channel intercom system that permits communication between the command desk and individual experimenters' stations and alternately with the flight crew (pilots, flight engineer, navigator). Radio communication with the ground or other aircraft also can be effected from the command desk. The console also controls the electrical power distribution to the experimenters' junctions boxes in the cabin (more fully described in Section 6).

4.3.2 The darkroom in the aft cabin on the port side (Fig. 4.1) is used only for loading or unloading film rolls or cameras. Film processing is not permitted on the airplane because of danger from spilled chemicals.

4.3.3 Two 5-cu-ft refrigerators are located on the starboard side of the cabin. The aft refrigerator is normally reserved exclusively for the storage of photographic film. The second refrigerator can be relocated and is not shown on Figure 4.1.

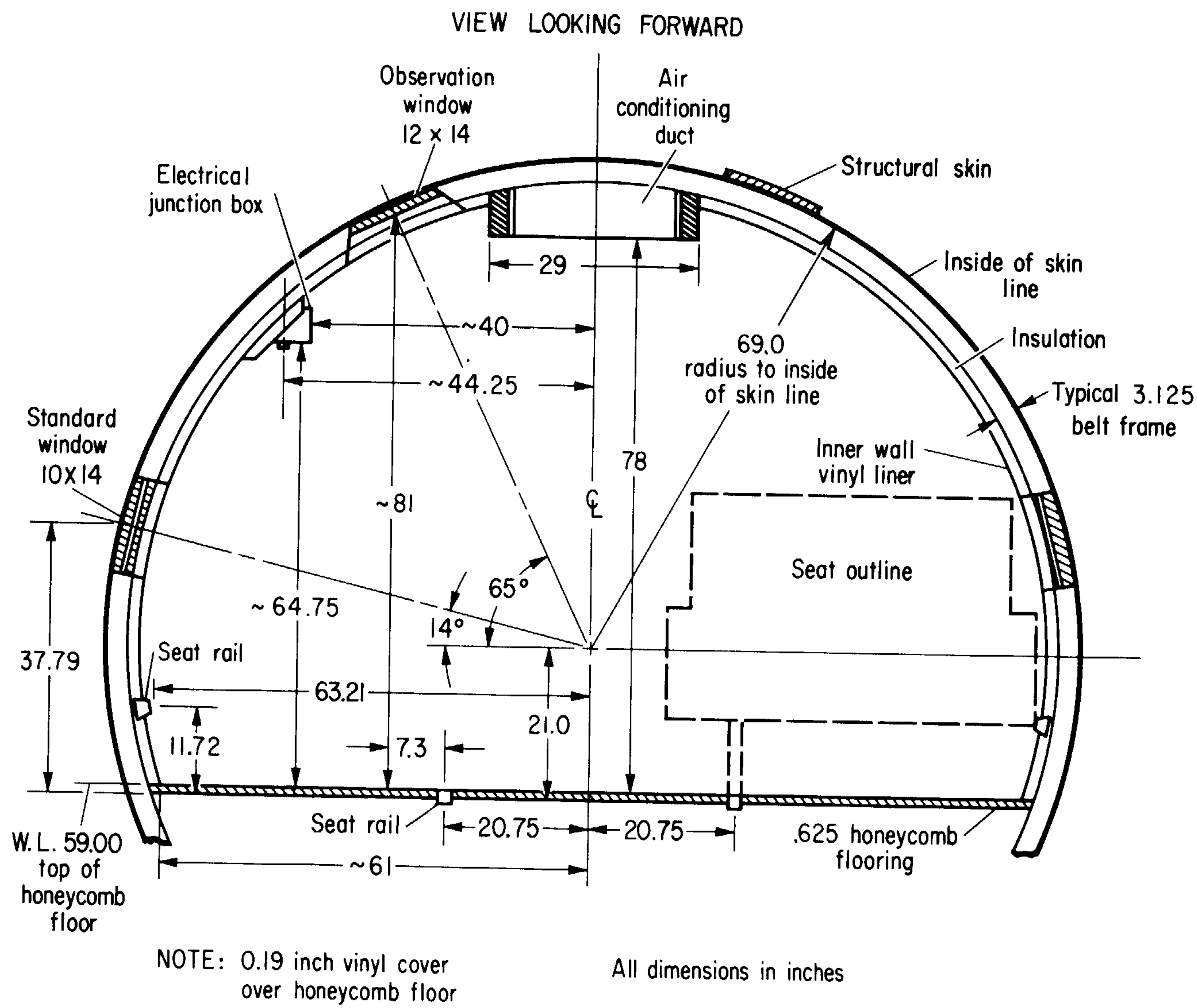
4.3.4 A total of 22 double passenger seats are available, 14 for the starboard side and 8 for the port side. The longitudinal spacing of the seats can generally be adjusted in 1-inch increments. The minimum center-to-center spacing for adequate knee room is 34 inches (we recommend 36). Seats do not have to be placed at regular intervals, but can be interspersed with experimental equipment along the cabin.

4.3.5 Life rafts, life vests, oxygen masks, fire extinguishers, and other safety equipment are distributed throughout the cabin. Numerous emergency oxygen masks which deploy automatically are located along the walls, starboard and port.



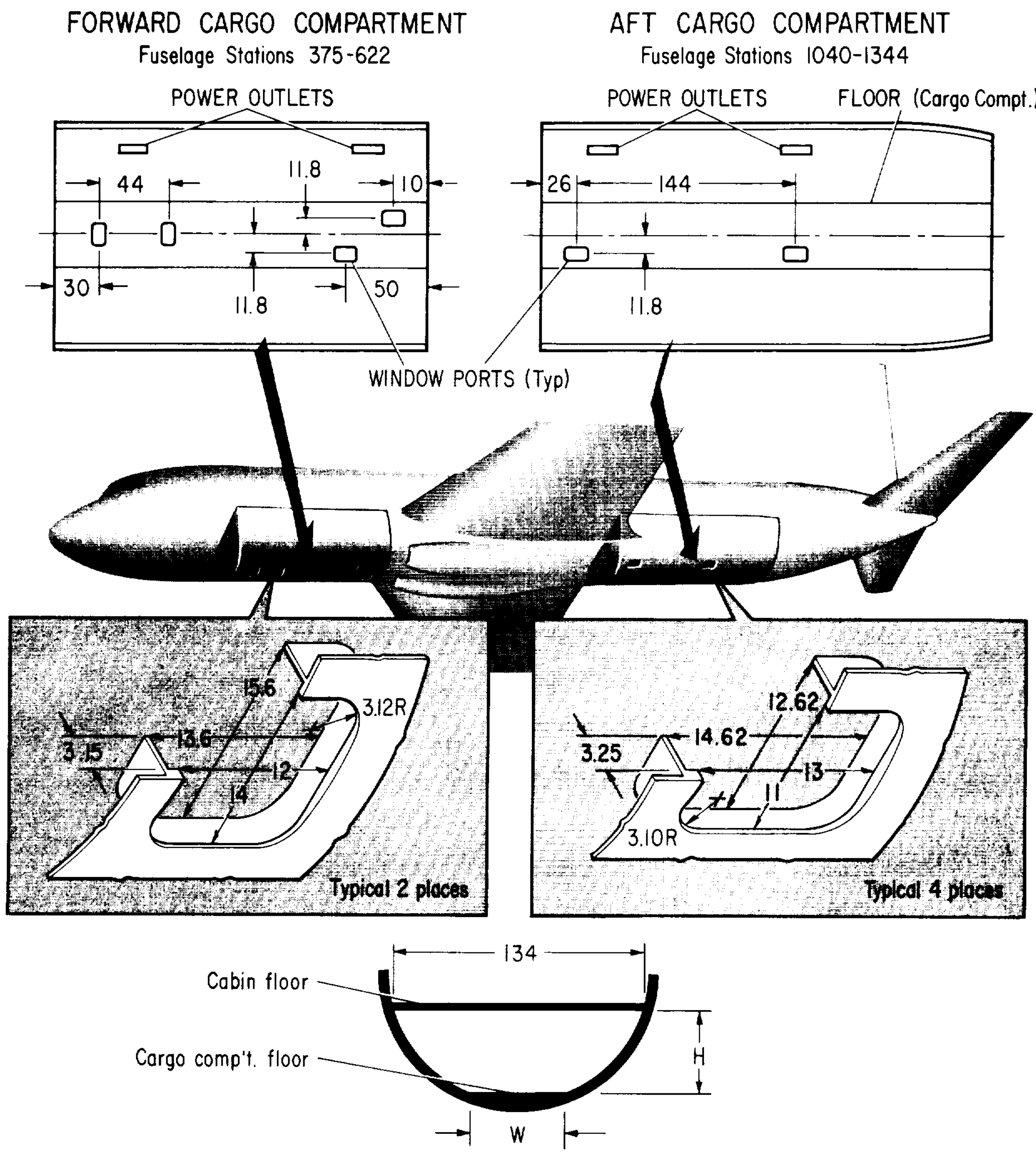
General cabin layout.

Figure 4.1 (Nov. 70)



Cabin cross section.

Figure 4.2 (Nov. 70)

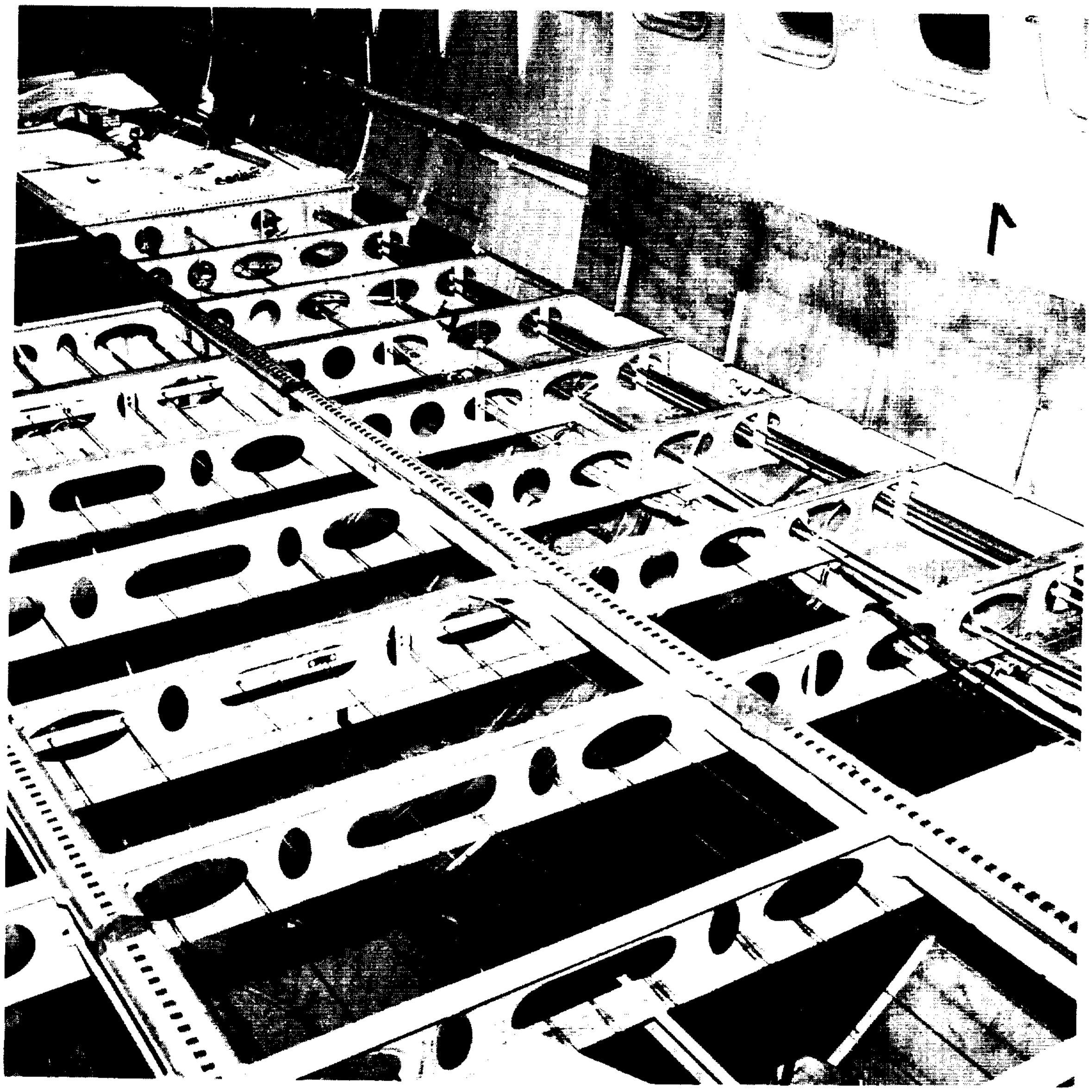


	LENGTH	W			H	
		FWD	CTR	AFT	FWD	AFT
FORWARD CARGO COMPARTMENT	247	22	40	39	42	38
AFT CARGO COMPARTMENT	304	39.5	39.5	33	42	33

All dimensions in inches

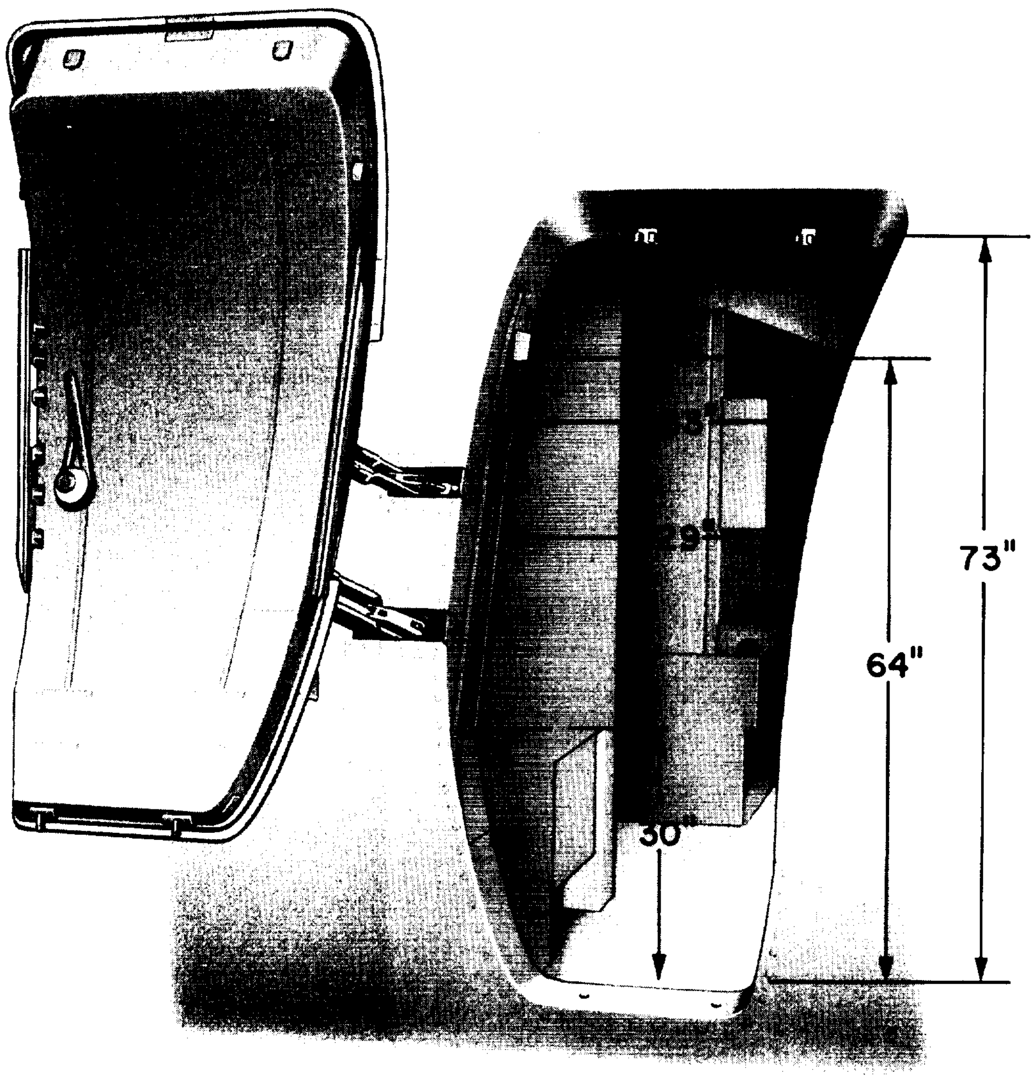
Layout and dimensions of cargo areas.

Figure 4.3 (Nov. 70)



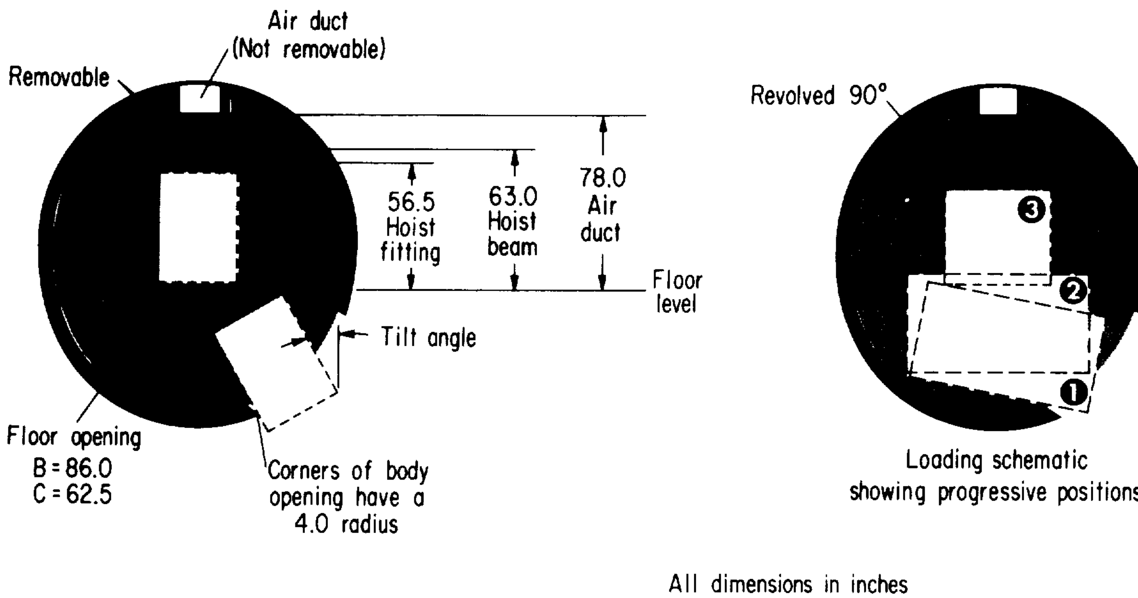
Cabin floor construction. This photograph was taken in area "F" (Fig. 4.1). Note seat rails, beams, control cables.

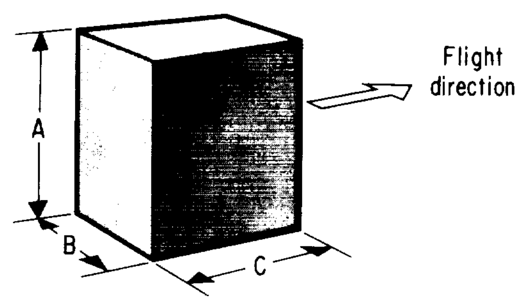
Figure 4.4 (Nov. 70)

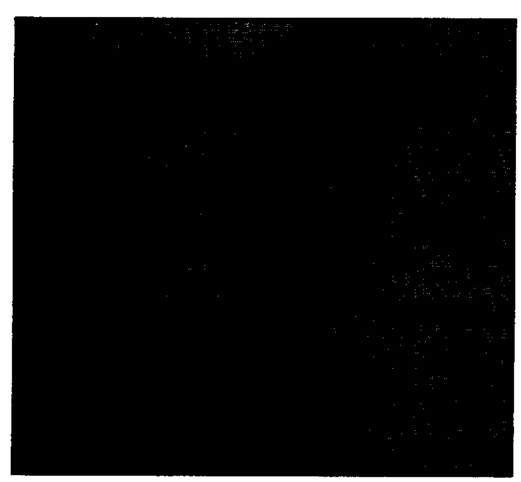


Dimensions of main cabin doorways. Forward door is shown here; structure seen through the door is the navigator's station (see Fig. 4.1).

Figure 4.5 (Nov. 70)

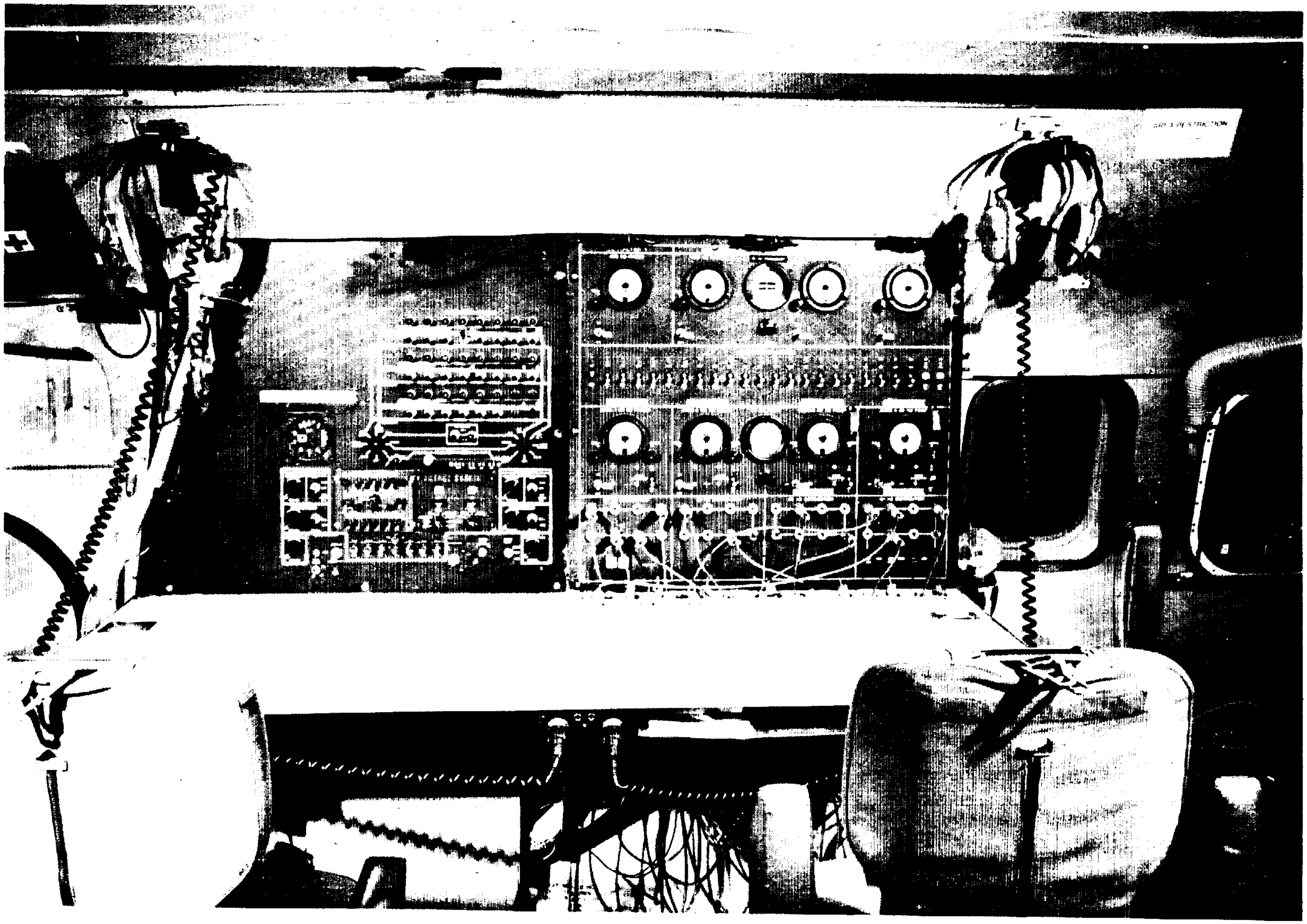






Loading of large items into the cabin.

Figure 4.6 (Nov. 70)



Flight Director's console.

Figure 4.7 (Nov. 70)

SECTION 5

EQUIPMENT CONSTRUCTION AND INSTALLATION

The installation of experimenters' equipment aboard the aircraft is one of the most demanding and time-consuming aspects of airborne research. Because of familiarity with the ease of travel by commercial airlines, experimenters often do not fully appreciate the problems encountered in securing airborne equipment so as to meet standard safety requirements.

The specifications, deadlines, and other requirements given in this Section are strictly enforced. Because of manpower limitations, construction defects usually cannot be corrected during equipment installation; thus, some experimenters may be required to withdraw at the last moment.

The standards described below fully meet or exceed all FAA requirements for the CV-990 type and category aircraft.

5.1 Load Factors - Safety Standards

All equipment, including racks, instruments, pallets, tie-down bracketry, and carry-on items, must be designed for the load conditions listed below. These load factors, when applied one at a time, must not produce a stress in any element of the equipment beyond the accepted yield point for the construction material.

	Load Factors	
Load Direction	Passenger Cabin	Cargo Areas
Forward	9.0 g	1.5 g
Down	7.0 g	7.0 g
Up	2.0 g	2.0 g
Side	1.5 g	1.0 g
Aft	1.5 g	1.0 g

The above requirements are for structural design of the equipment. It is not required that alignment, calibration, or other instrumental functions be maintained under these load conditions.

5.2 Allowable Loads - Safety Standards

5.2.1 Passenger cabin area loading

The maximum allowable load that can be applied to each seat track attachment fitting is listed in the table below. For columns I, II, and III, the sum of the loads on any 32-inch length of track must not exceed the listed values. Therefore, the spacing between maximum loads must be at least 32 inches. For column IV (loads produced by vertical couple under the 9.0 g load factor), there is no minimum spacing requirement.

	Allowable Loads (lb) per Track Fitting			
	I Fore & Aft Shear (9.0 g)	II Vertical (7.0 g)	III Lateral (1.5 g)	IV Vertical Couple (9.0 g)
Side Tracks (Port & Starboard)	1785	1750	1800	1750
Port Floor Track	2195	1800	0	3165
Starboard Floor Track	3990	3200	0	5830

5.2.2 Cargo area loading

For normal static loads with 1 g down:

	Forward	Aft
Capacity (ft^3)	491	497
Maximum load (lb)	9820	9900
Maximum loading (lb/ft^2)	100	100
Maximum linear loading (lb/ft)	477	396

The above capacities and loadings are not entirely available to experimenters. The forward cargo compartment contains frequency converters and intercom gear which weigh about 500 pounds. Also, for missions based away from Moffett Field, cargo space must be provided for aircraft parts, experimenters' support equipment, and luggage. NOTE: Personnel are not permitted to occupy either of the cargo areas during takeoff and landing.

5.2.3 Window frame loading

The zenith, 65-degree, nadir, and cabin side window frames can support experimental equipment. However, it is mandatory that experimenters contact the Airborne Science Office to obtain all information, guidance, and preliminary approval of plans for attaching equipment to these windows.

Each of the two zenith and six nadir windows has eight hardpoints for attaching equipment as shown in figure 5.1. The maximum allowable loads for each of these hardpoints are

Fore and aft	1190 lb
Vertical	724 lb
*Lateral	426 lb

*The four hardpoints immediately adjacent to the window are the only ones designed to accept a lateral load.

Only shear and/or tension loads are permitted at the window hardpoints. No design will be approved which imparts a moment at a window hardpoint.

5.3 Construction Constraints

The load factors specifications presented in paragraph 5.1 are fully applicable to this section.

5.3.1 Aircraft fasteners and welding

Aircraft structural fasteners (MS or NAS standards) <u>must</u> be used for all structural members. These fasteners must be secured by self-locking nuts or safety wire. In addition to mandatory use for structural members, this type of hardware should also be used for other elements of the equipment whenever possible. A list of approved suppliers of these aircraft structural fasteners is given in figure 5.2. Data sheets giving detailed nomenclature and engineering specifications for this hardware are available on request from the Airborne Science Office.

Welding of structural members of experimental equipment is acceptable. However, it <u>must</u> be high quality work performed by a welder <u>currently</u> certificated to the MIL-T-5021C Specification.

5.3.2 Equipment racks

A standard double-bay equipment rack which attaches directly to the seat tracks is available for use by experimenters. It is designed to accept standard 19-inch wide rack-mounted equipment. This rack must be used for mounting experimental equipment in lieu of laboratory-type electronics racks. Figure 5.3a is a photograph of the rack and Figure 5.3b gives pertinent dimensions. Equipment may be mounted facing fore or aft in either bay.

The allowable weight of equipment per rack bay is 200 pounds and the allowable overturning moment for all components within the rack is 8000 inch-pounds. These values take into account the load factors and allowable loads given in sections 5.1 and 5.2. For installations which do not exceed these allowable values, a stress analysis of the rack is not required. The moment arms are measured vertically from the bottom edge of the bay opening (see Fig. 5.3b) to the center of mass of the component.

The Airborne Science Office has scale drawings of these racks which will be sent to experimenters on request. It is recommended that the experimenter make a preliminary scale layout of his equipment in the rack (taking into account the allowable loads and moments given above) and prepare a list of sizes (panel height and depth of the units) and weights. A rule-of-thumb in loading the racks is to place the heaviest items near the bottom when possible. The cognizant Ames engineer will check the loading and moments and will determine the internal support and bracing required to distribute the loads properly to the rack structure. A supply of specially designed trays and straps is available for this purpose. The trays and straps are shown in Figure 5.3c, and Figure 5.3d illustrates the installation technique. In case a rack is shipped to the experimenter for installing his equipment, a nominal supply of trays and straps (including NAS hardware, special tools, drawings, and specifications) will be included.

The racks can also be used as support platforms for mounting equipment. This feature has proved very useful, especially for experiments which utilize the 65° ports. Figure 5.3e illustrates such an application. The loads and moments resulting from such installations are considered individually (i.e., a stress analysis will probably be needed even if the total weights and moments do not exceed the values given above).

In addition to the standard rack described above, four "low-boy" versions of the rack have been constructed. Figure 5.3f is a photograph of the low-boy rack and Figure 5.3g gives pertinent dimensions. These low racks are intended primarily as platforms to support equipment which utilize the 14° ports and to support heavy equipment (e.g., tape recorders). The procedure for loading the bays in these racks is identical to that for the standard racks; the Ames engineer must be consulted when equipment is to be mounted on top of these racks.

To aid experimenters in the design of equipment to be placed on top of the racks, a cross-section view of the CV-990 fuselage is shown in Figure 5.3h. The figure includes the outlines and dimensions of the special racks and shows their position relative to the 14° and 65° ports.

5.4 Mounting Techniques

All items, regardless of size, must be secured during takeoff and landing. While airborne, it is permissible to relocate items which are soft (or which can be made soft by padding) and which weigh less than ten pounds. However, because of frequent gust loads, these items must again be secured after relocation. Personal briefcases, cameras, binoculars, etc., are definitely included in this requirement.

5.4.1 Cabin area

All cabin equipment must be supported by the seat tracks. Bolting to the aircraft floor is NOT permitted. NASA furnishes, on loan, the seat track clamps. See Figures 4.2, 4.4, 5.4, and 5.5 for photographs and dimensions of the seat tracks and attachment clamps.

Direct attachment of equipment to the tracks through seat track attachment clamps is preferred; however, one-inch thick plywood pallets may be used. Tripods are specifically included in this requirement. Figure 5.6 shows some typical installations. Equipment may be bolted to brackets restraining the plywood and/or attached to the plywood by means of baseplates. Baseplates must be secured to the plywood by T-nuts and bolts. Small items weighing less than 25 pounds (i.e., tool boxes, spare parts boxes, etc.) may be secured directly to the equipment framework or to the plywood pallets by T-nuts, safety belts, or cables.

Equipment should be mounted on pallets or other framework by the experimenters. However, since dimensions vary slightly along the fuselage, do not drill holes for mounting the seat track clamps. The mount should be designed so that attachment to the seat tracks can be accomplished by shimming and drilling. The use of eccentric holes or slots for this purpose is unacceptable.

5.4.2 Cargo area

Experimenters equipment can be mounted in both the fore and the aft cargo areas. Equipment is secured either on the floor or on the curved sidewalls by utilizing existing floor and sidewall bolts. Such installations are considered individually and must be discussed with Ames personnel prior to design of tie-down bracketry.

Baggage is secured by means of ropes, cables, or nets which are attached to eyelets located along the walls and floor.

5.4.3 Exterior and other areas

It is possible to mount equipment exterior to the aircraft on certain specified hatch doors, window adapters, etc. Some areas within the tail and the aircraft gear compartments may be used under special circumstances. All such cases are treated individually. Experimenters who contemplate such installations should visit Ames Research Center at least six months in advance to examine the aircraft and discuss plans in detail with cognizant NASA personnel.

5.5 Floor Plan

A floor plan based on experimenters' requirements for equipment, auxiliary systems, and seating is usually provided by Ames. In some cases, however, a complete floor plan may be proposed by another organization which is coordinating the efforts of several investigators. Requests for a single location of limited size as well as proposals for a complete floor plan should take into account the following requirements (in addition to the loading constraints).

Cabin floor loading by experimental equipment should not exceed an average of 40 pounds per square foot under a static condition of 1 g down. This limit can be used for initial estimating of required floor space.

Allow two inches longitudinally for final adjustment of equipment and for proper attachment of seat track clamps.

Specify "elbow room" needed by experimenters around each piece of equipment or take this into account when preparing a complete floor plan.

Observe the seat space requirements as given in paragraph 4.3.4.

Provide for an aisle at least eighteen inches wide along the entire length of the cabin. This aisle need not be centered nor straight.

Take into account permanent or semi-permanent installations (e.g., operational consoles, refrigerators, hatches). Some of these installations are shown in Figure 4.1. Provide space for life rafts if any portion of the program involves over-water flights.

Equipment may be mounted in areas F and G unless in-flight access to the rear cargo compartment is needed. In this case, area G should be left clear.

In-flight access to the electrical power and intercom equipment through access hatch C is often required. Thus, hatch C is to be left clear.

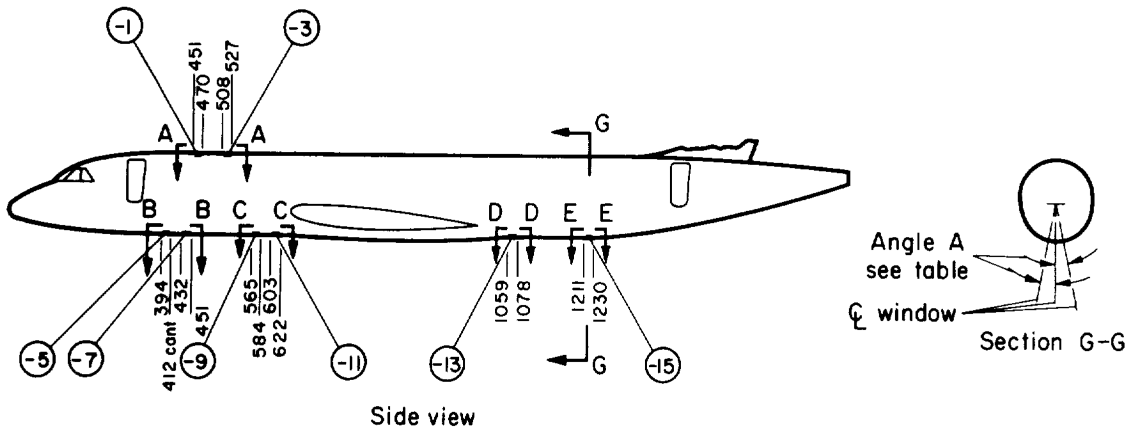
5.6 Equipment Certification

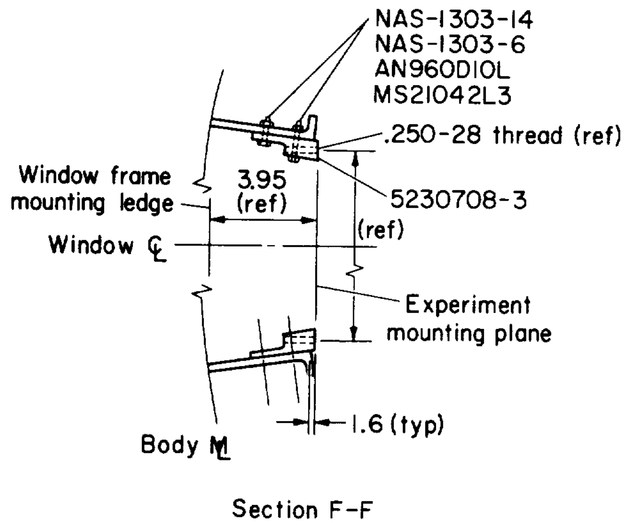
It is the experimenter's responsibility to design and construct his equipment in accordance with all specifications. Problems may, of course, be discussed with Ames personnel at any time.

Experimenters are required to submit detailed blueprints of their equipment which show dimensions, materials, bolt types and patterns, and component weights. If possible, photographs of the equipment should also be furnished. Stress calculations must accompany the blueprints. These calculations must include at least the following: load analysis of floor and side seat tracks, analysis of support and tie-down structure, and an analysis of restraining structure for components.

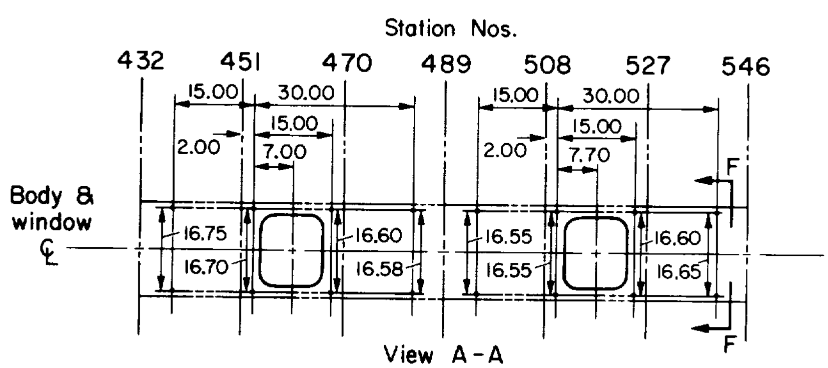
All of the above material should be submitted at least eight weeks prior to scheduled installation of the equipment aboard the aircraft. A longer required lead time may be specified by the Program Manager in cases of complex installations. The material will be analyzed by Ames or by a contractor under Ames supervision, and changes will be requested as needed. Preliminary approval should be obtained from Ames prior to shipment of equipment.

Actual equipment construction, weight, center of mass, and resultant loading are verified at Ames before final approval for installation aboard the aircraft is given. Allow time for this verification when planning installation time.





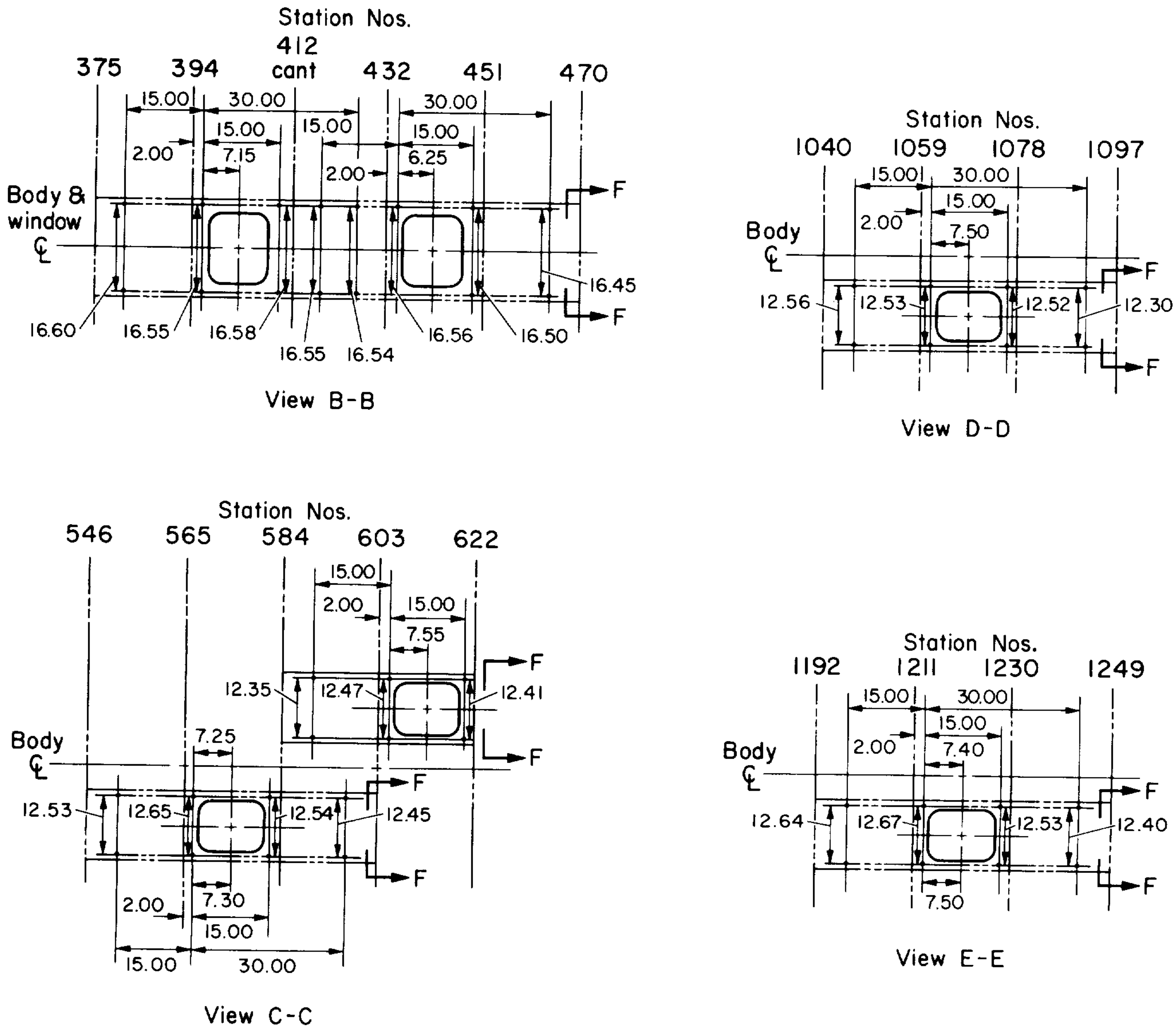
Inst dash No.	Angle A
-1	0°
-3	0°
-5	0°
-7	0°
-9	10° 35'
-11	10° 35'
-13	10°
-15	10°



a) Zenith hardpoints

Zenith and nadir window hardpoints.

Figure 5.1 (Nov. 70)



b) Nadir hardpoints

Figure 5.1 (Nov. 70) (concluded)

1. Standard Pressed Steel Company
   2701 Harbor Boulevard
   Santa Ana, California 92703

2. Kaynar & Greer Manufacturing Company, Inc.
   800 S. State College Boulevard
   Fullerton, California 92631

3. Voi-Shan
   8463 Higuera Street
   Culver City, California 90230

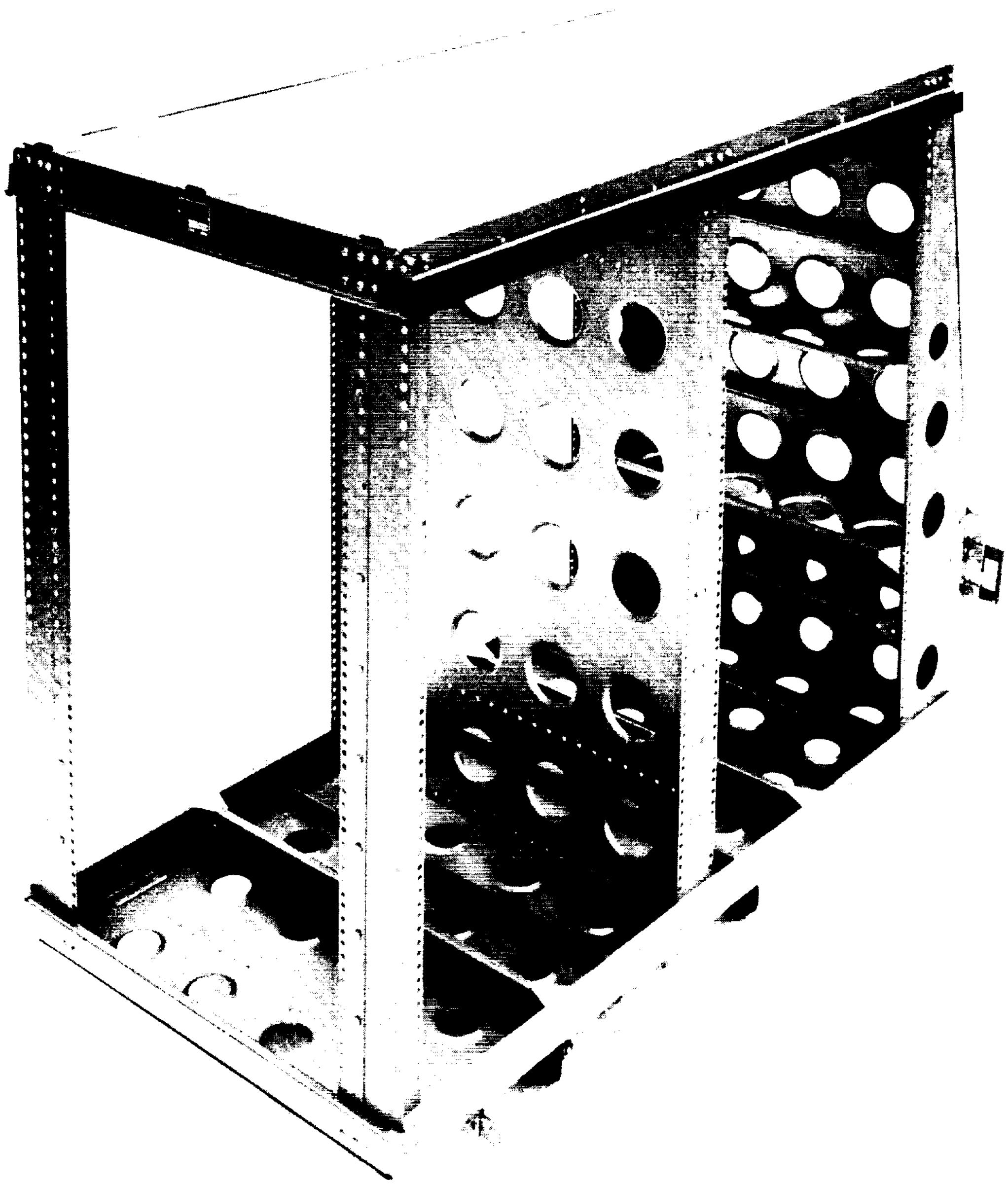
4. Elastic Stop Nut Corporation
   16150 Stagg Street
   Van Nuys, California 91406

5. Hi-Shear Corporation
   2600 West 247th Street
   Torrance, California 90505

6. Air Industries of California
   1700 W. 132nd Street
   Gardena, California 90249

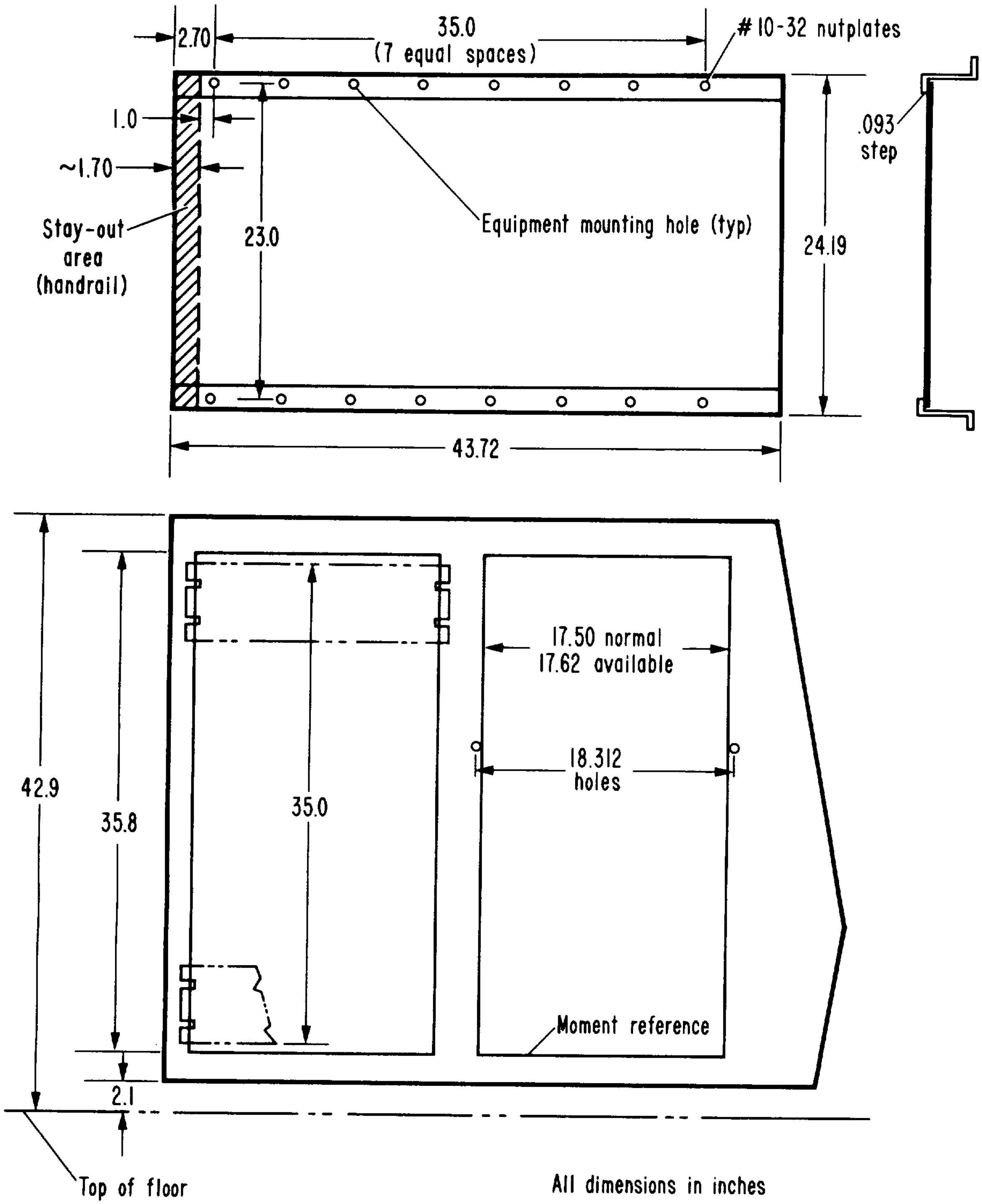
List of approved suppliers of NAS
(National Aerospace Standard) hardware.

Figure 5.2 (Nov. 70)



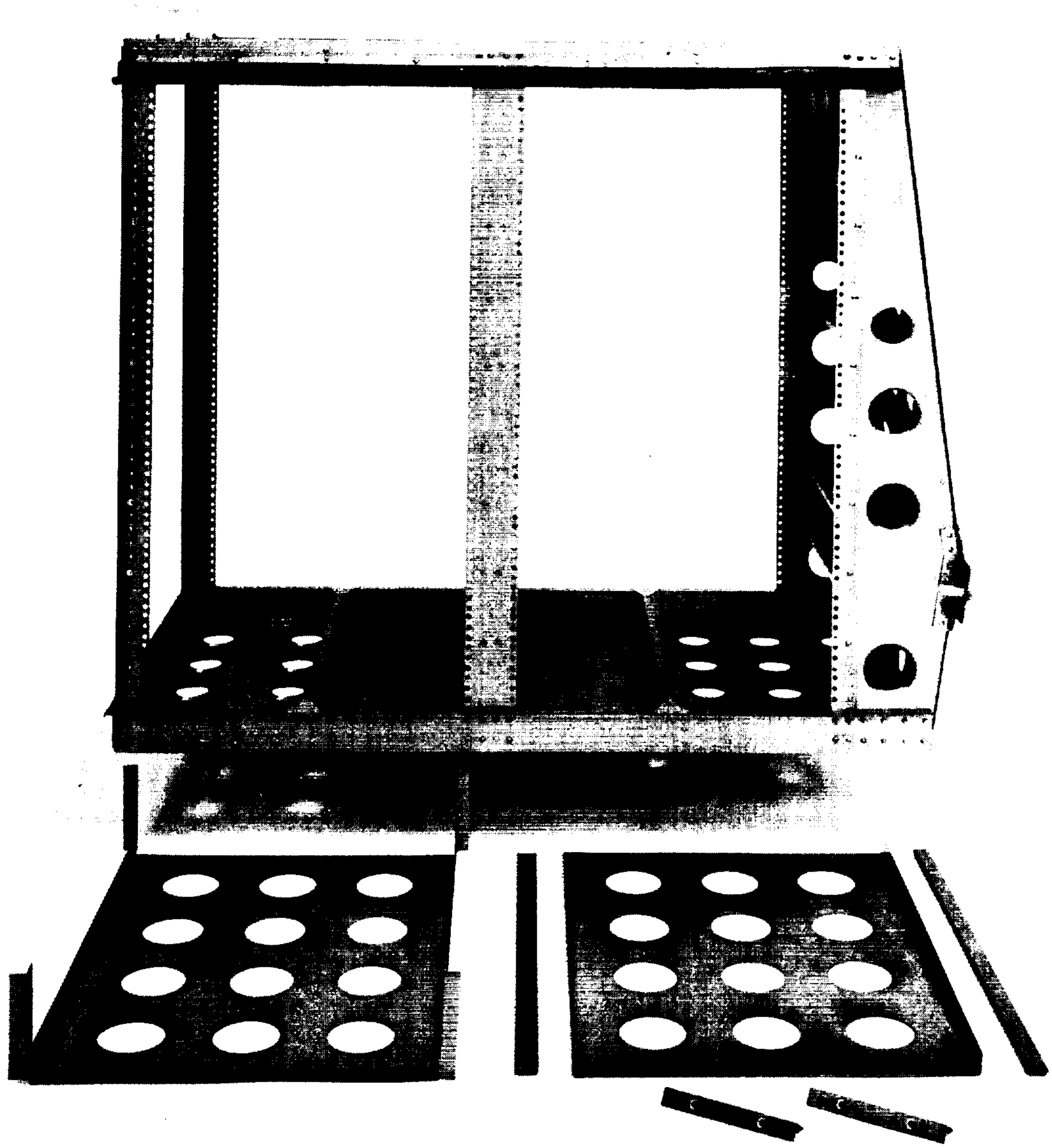
a) Photograph of standard rack
The CV-990 standard equipment racks.

Figure 5.3 (Nov. 70)



b) Standard rack dimensions

Figure 5.3 (Nov. 70) (continued)



c) Rack, trays, and straps

Figure 5.3 (Nov. 70) (continued)

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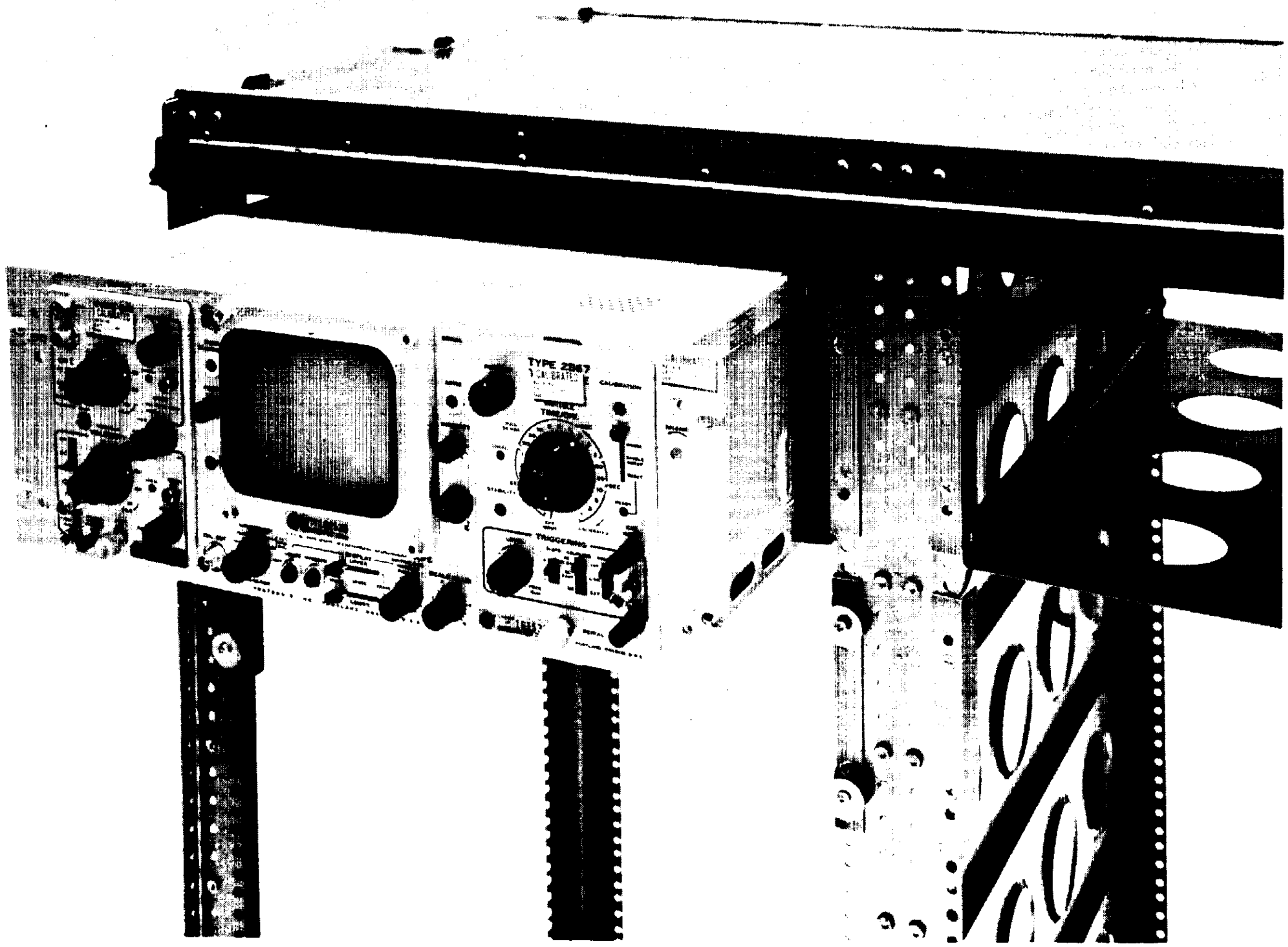
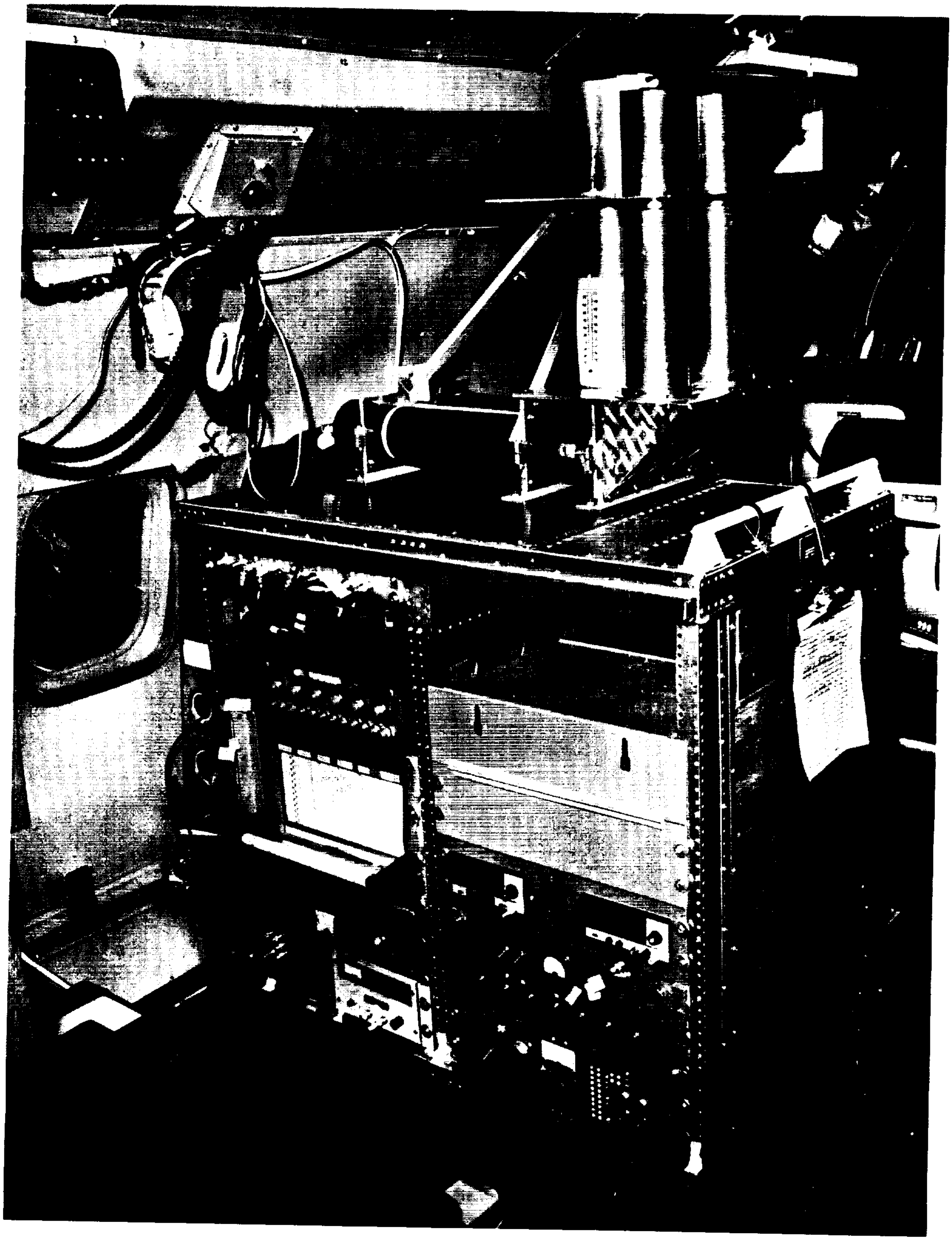


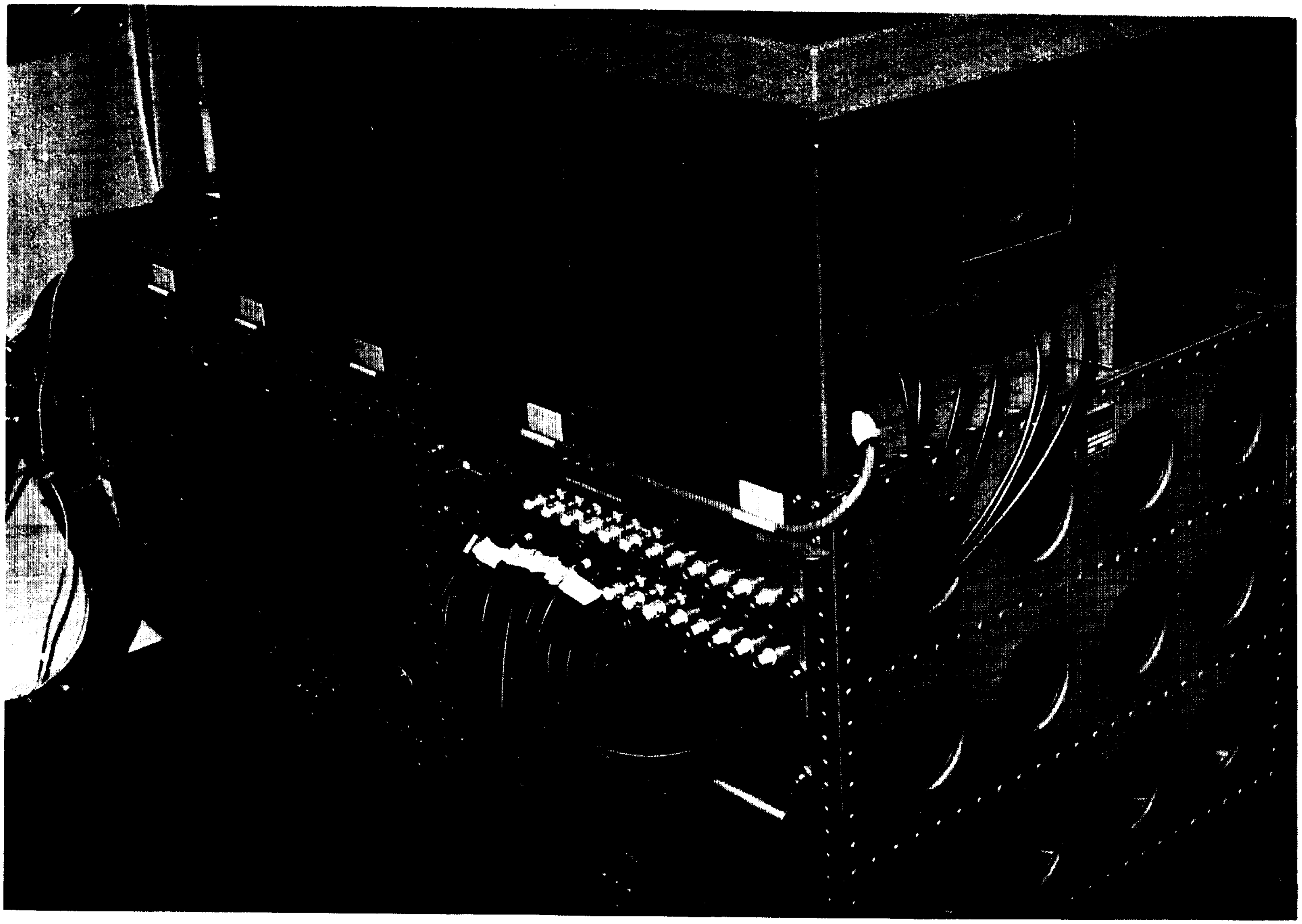
d) Typical rack-mounted installation

Figure 5.3 (Nov. 70) (continued)



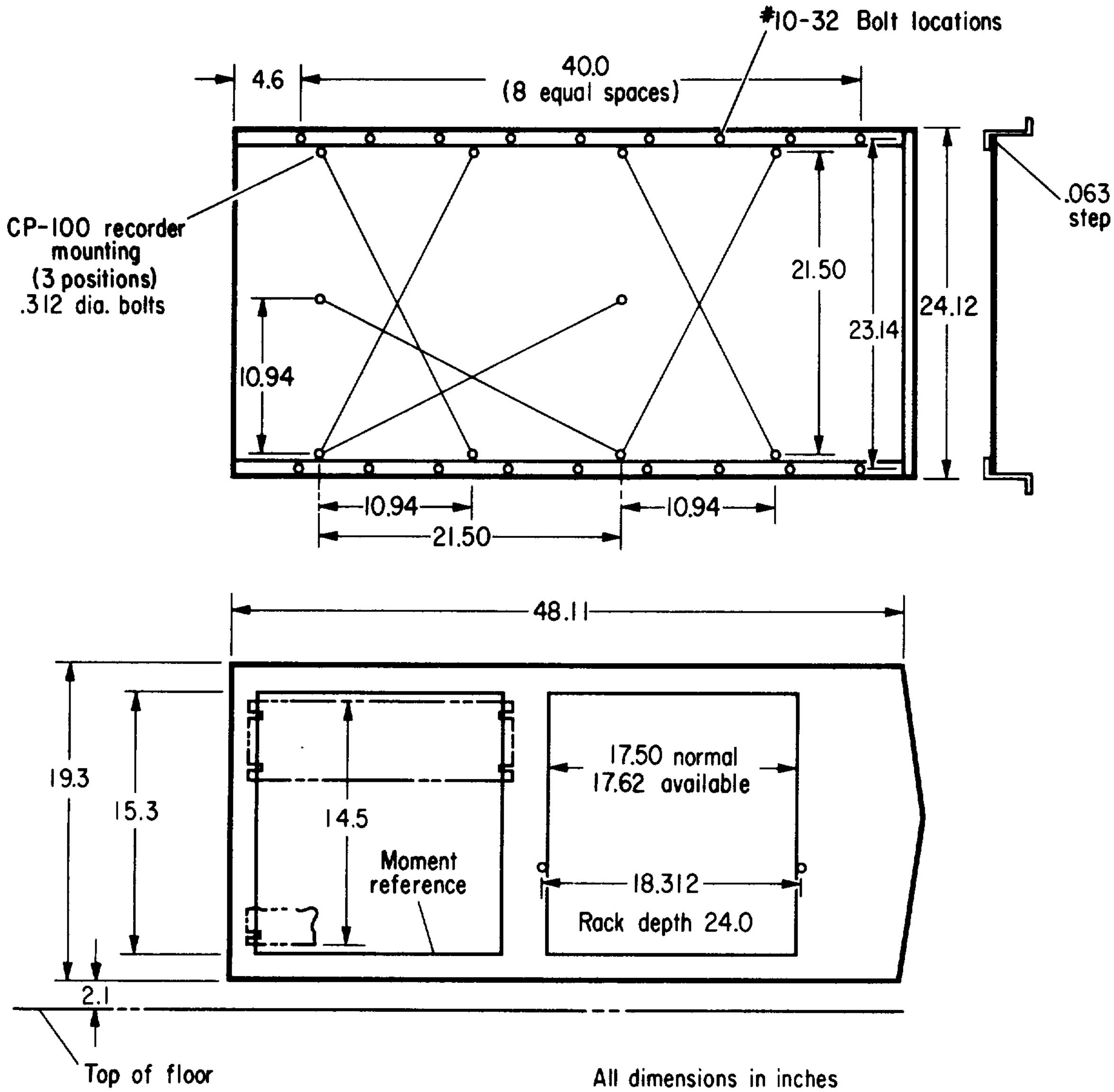
e) Upward-looking experiment using standard rack as support platform.

Figure 5.3 (Nov. 70) (continued)



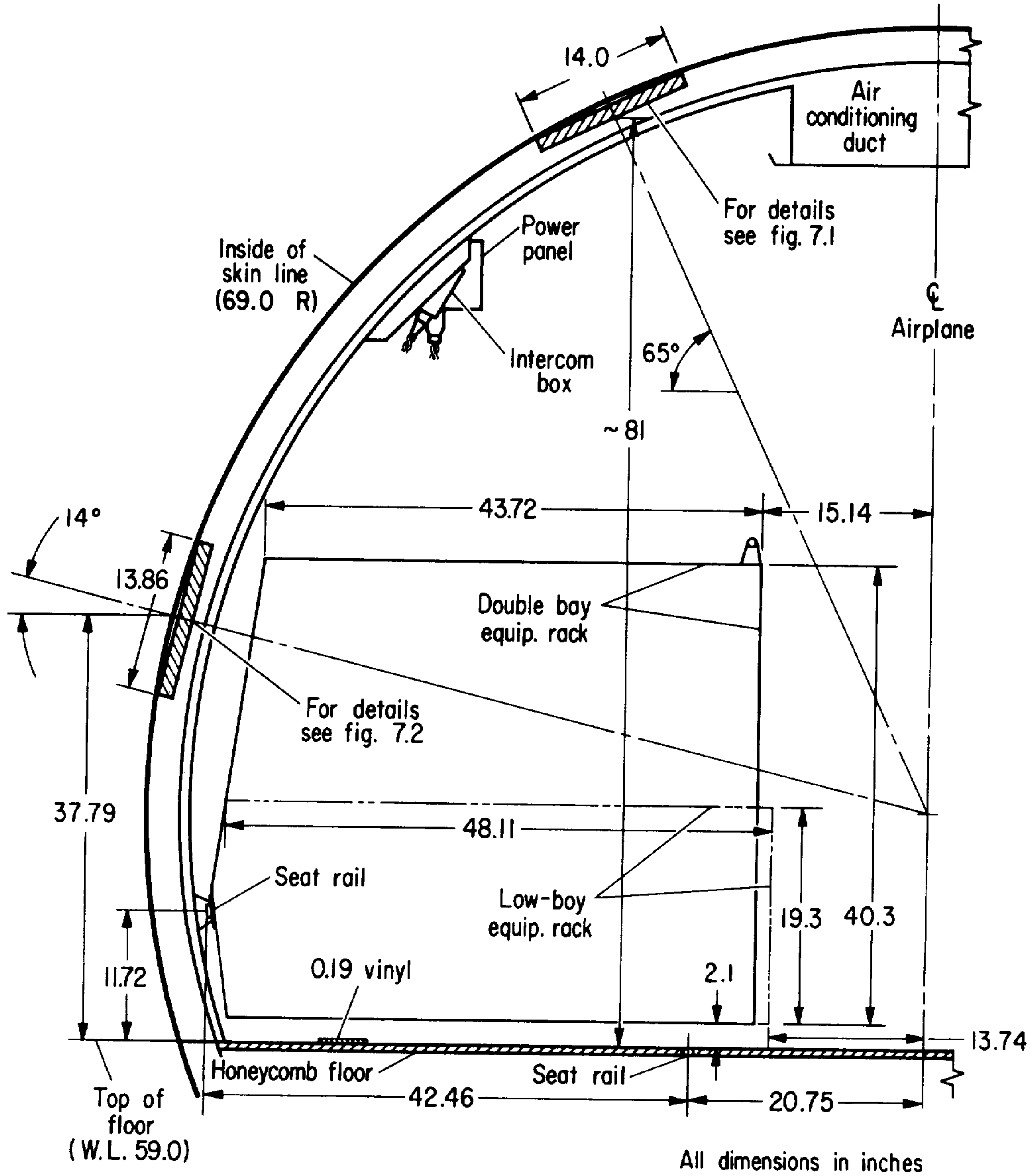
f) The low-boy rack

Figure 5.3 (Nov. 70) (continued)



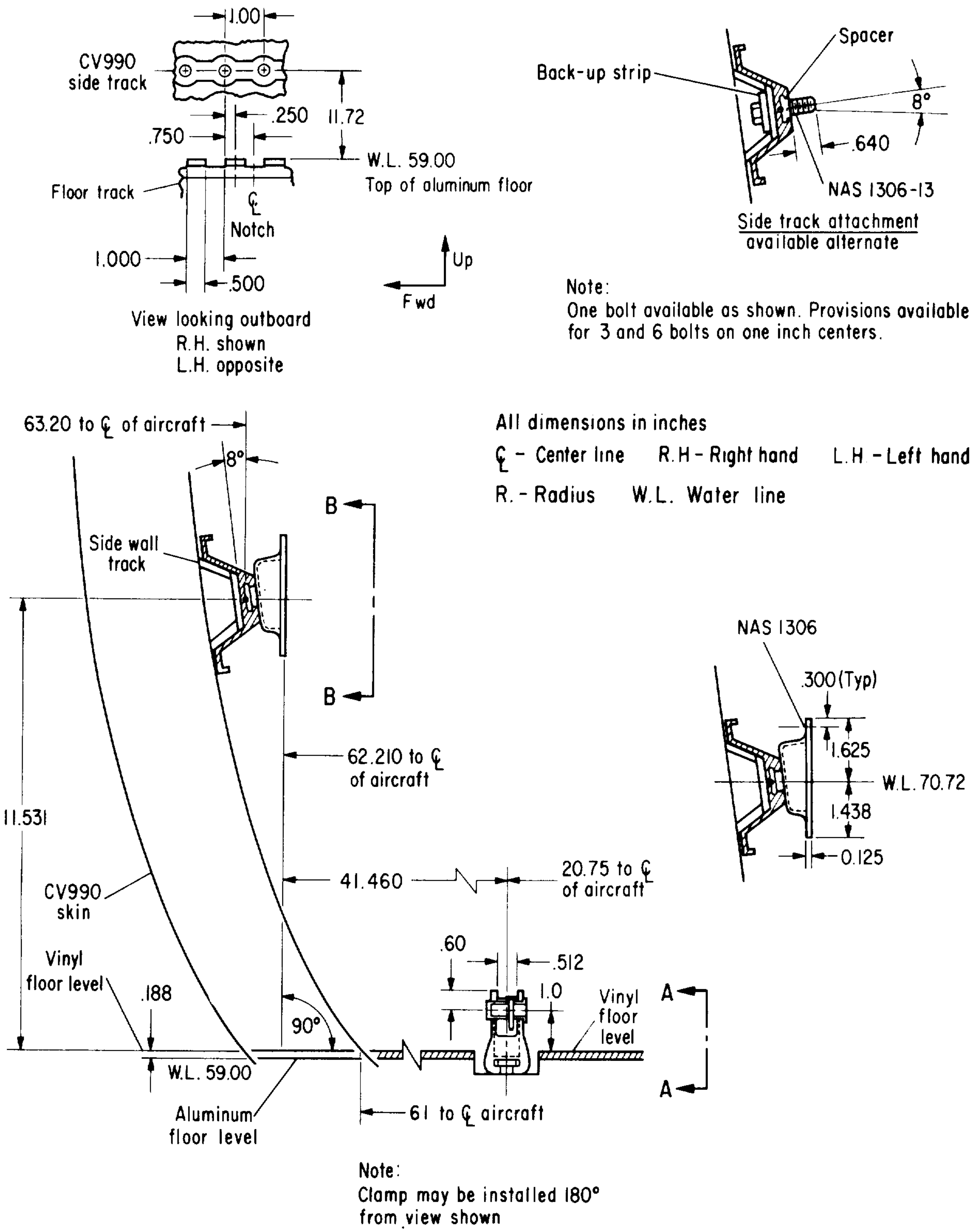
g) Dimensions of low-boy rack

Figure 5.3 (Nov. 70) (continued)



h) Relative locations of equipment racks and view ports

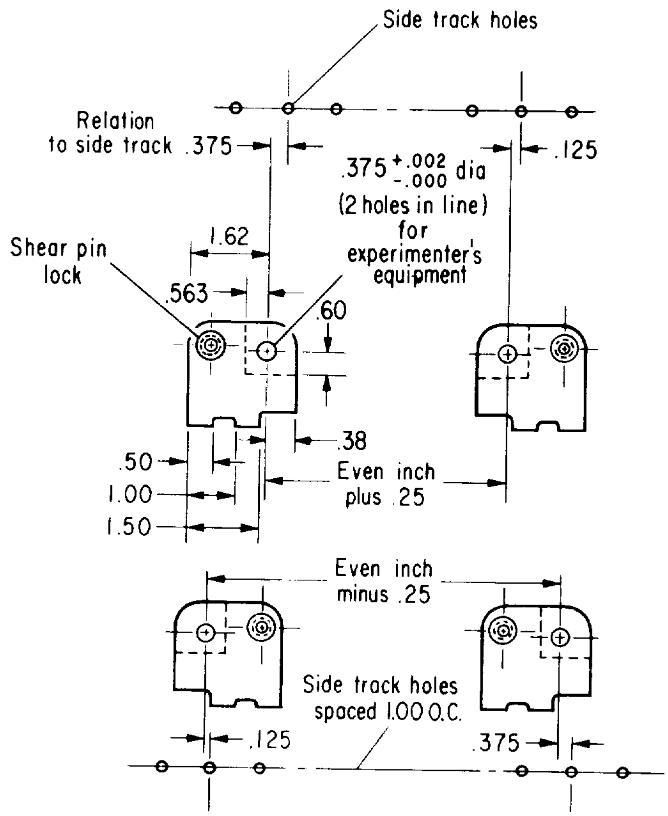
Figure 5.3 (Nov. 70) (concluded)



a) Overall dimensions

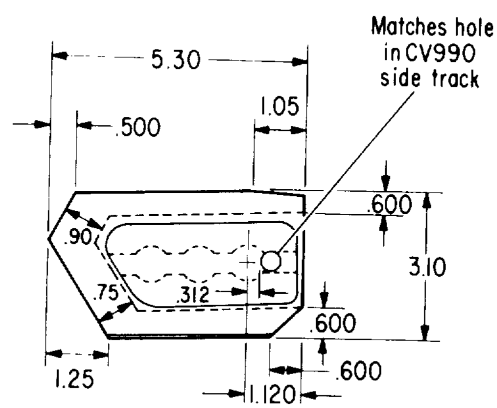
The seat tracks and clamps.

Figure 5.4 (Nov. 70)



View A-A

All dimensions in inches



View B-B

b) Views A-A and B-B

Figure 5.4 (Nov. 70) (concluded)

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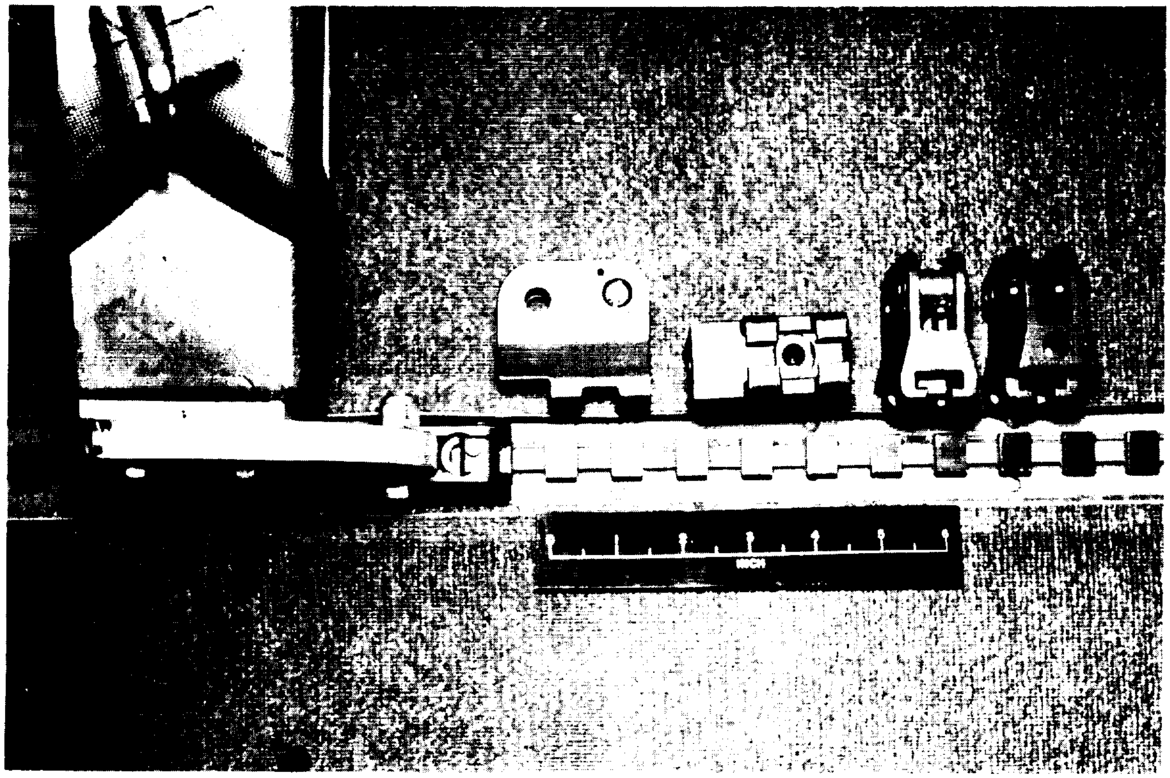

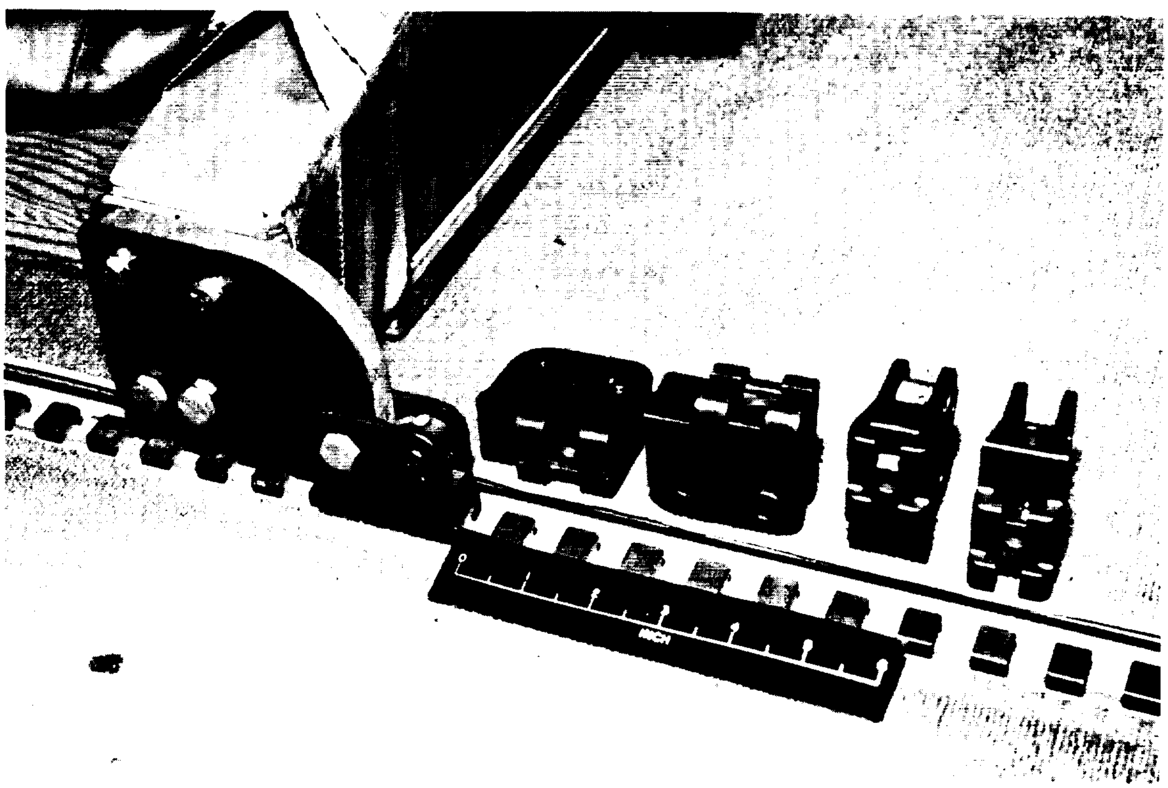

Floor seat track clamp.

Figure 5.5 (Nov. 70)

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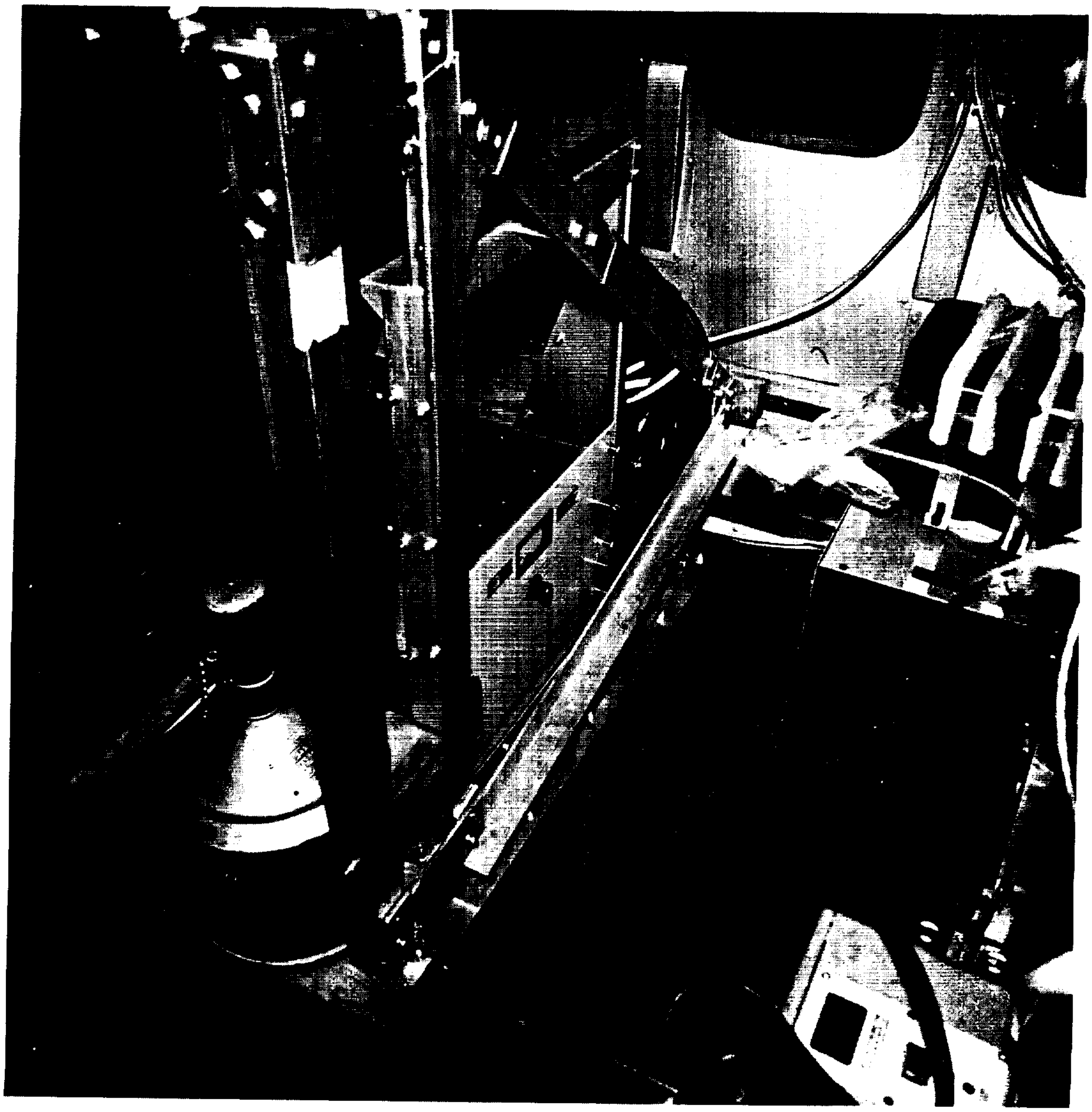

a) Plywood pallet held to seat tracks by aluminum angle stock; liquid nitrogen bottle and light-weight boxes tied with steel straps

Typical method of securing equipment to seat tracks.

Figure 5.6 (Nov. 70)

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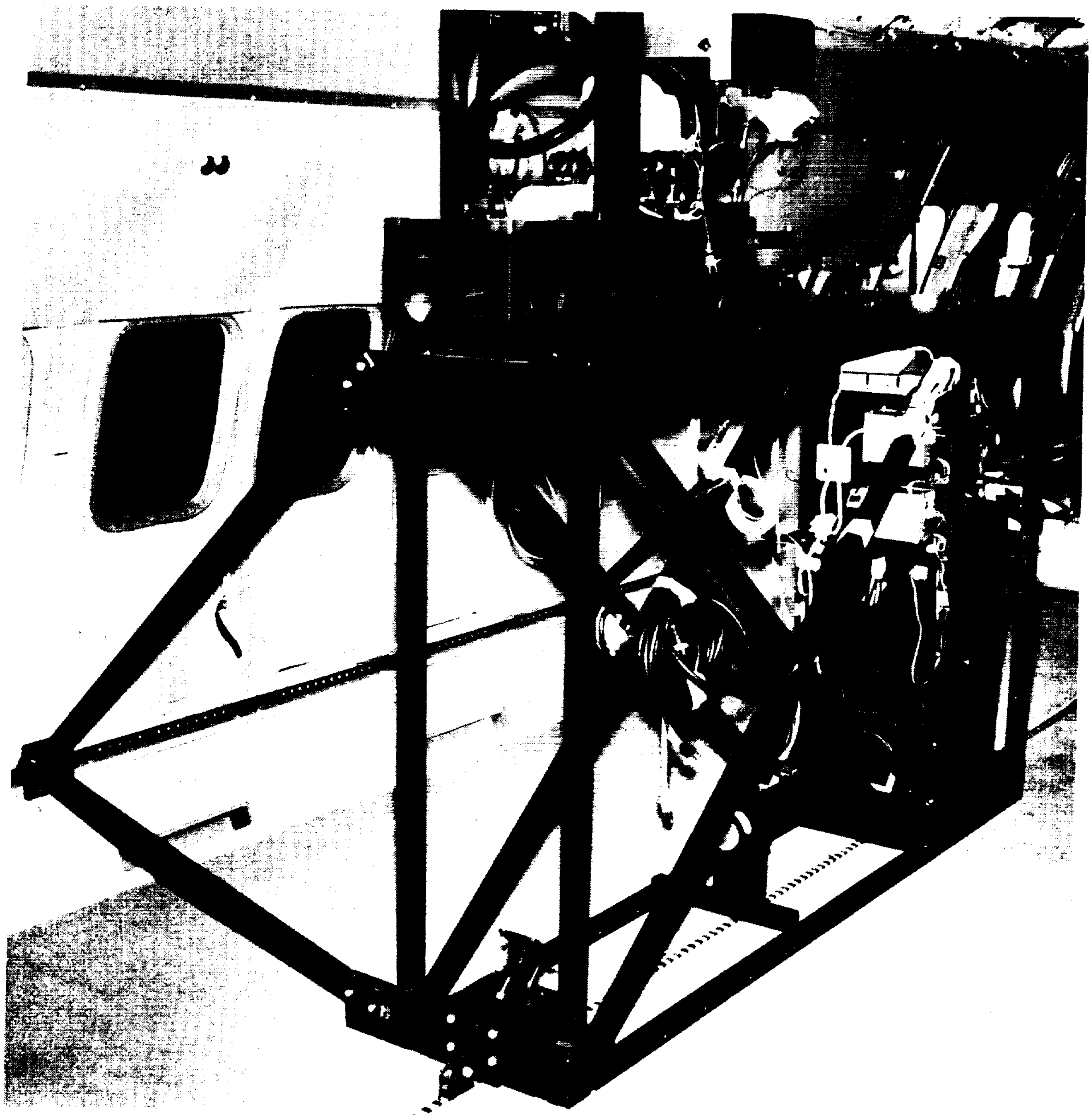

b) Equipment stand tied directly to seat tracks; welded cross-bracing

Figure 5.6 (Nov. 70) (continued)

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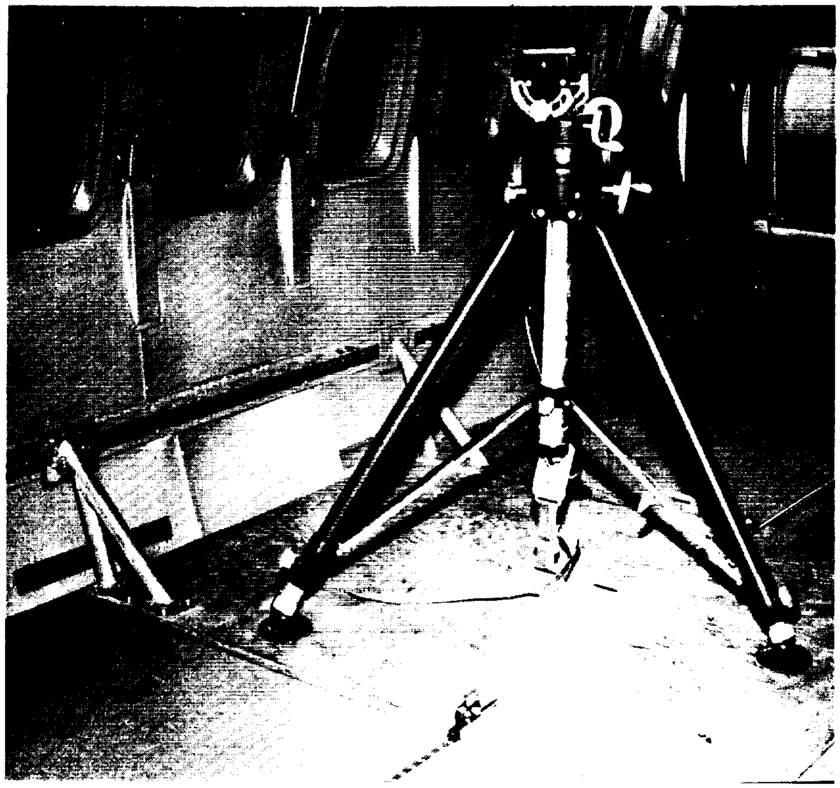
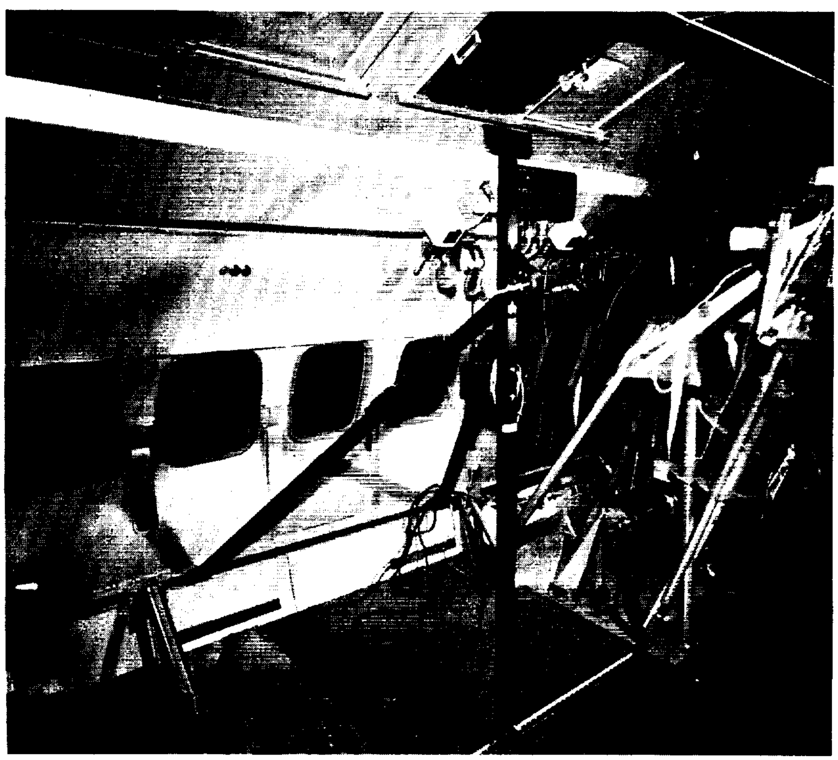




c) Mounting of tripods by means of base plates and directly to seat tracks. Note safety strap on pallet-mounted tripod.

Figure 5.6 (Nov. 70) (concluded)

SECTION 6

ELECTRICAL POWER

6.1 Summary Specifications

The basic specifications for experimenters' electrical power are as follows:

a) 400 Hz ±1%; 200/115 V ±1.5%; 3-phase, 4-wire, wye-connected. Approximately 40 KVA available.

b) 60 Hz ±0.25%; 115 V ±1%. Approximately 14 KVA available.

In addition, individual dc supplies operating from 400 Hz power are available on request. Their output typically varies nearly linearly from 28 V at no load to 24 V at the maximum load of 20 A. For safety reasons, acid-type batteries are not permitted on board.

6.2 Aircraft Power Source and Frequency Converters

The basic power source consists of a 40 KVA generator in each of the four jet engines, producing 200/115 V, 400 Hz, three-phase, four-wire, wye-connected power. The "return" wire of the system is tied to the aircraft structure; that is, the aircraft structure is the "ground" point for the aircraft's electrical system. Constant-speed drives hold the frequency within ±1%; the line to neutral voltage is regulated within ±2.5 V. The four aircraft generators are normally paralleled on a synchronizing bus, but they can also be switched at the flight engineer's panel in the cockpit so as to operate independently.

Four solid state converters (Unitron PS-62-66CP) are installed in the forward cargo compartment, which is pressurized and easily accessible in flight (Hatch C, Fig. 4.1). Each converter has a rated output of 3.5 KVA, 115 V ±1%, single phase, 60 Hz ±0.25%. The 60 Hz circuit is a two-wire circuit and the "return" lead is tied to the aircraft structure.

6.3 Outlets for Experimenters' Electrical Power

Outlet boxes for both 400 and 60 Hz power are located throughout the passenger cabin (Figs. 4.1, 4.2) and the two baggage compartments. Each box contains two independently energized sets of outlets (Fig. 6.1). There are "on-off" switches at each box for the convenience of the experimenter, but the primary control and distribution of power is at the Flight Director's console (see Section 4.3.1 and Fig. 4.7).

6.3.1 Locations

In the passenger cabin, eight outlet boxes (16 independent stations) are spaced along the length of the port wall (Figs. 4.1, 4.2, 6.1). In the baggage compartments, three outlet boxes (6 independent stations) are located as follows.

Forward baggage hold: belt frame 463 and 537

Rear baggage hold: belt frame 1182

(See Section 4.1 and Fig. 4.1 for explanation of "belt frame number" nomenclature.)

6.3.2 Connections to outlet boxes

The connectors to the outlet boxes are as follows:

60 Hz - MS 3106A-20-23P

400 Hz - MS 3106A-24-22P

The wire must be equivalent to aircraft wire, Deltabeston No. SI-57403-BC, Alpha No. 1385, gauge No. 14 or larger.

Ames can supply the connector cables between the outlet boxes and the experimenter's load. These cables are made in 12 and 20 ft lengths. A few longer cables are also available.

6.4 Power Available to Experimenters

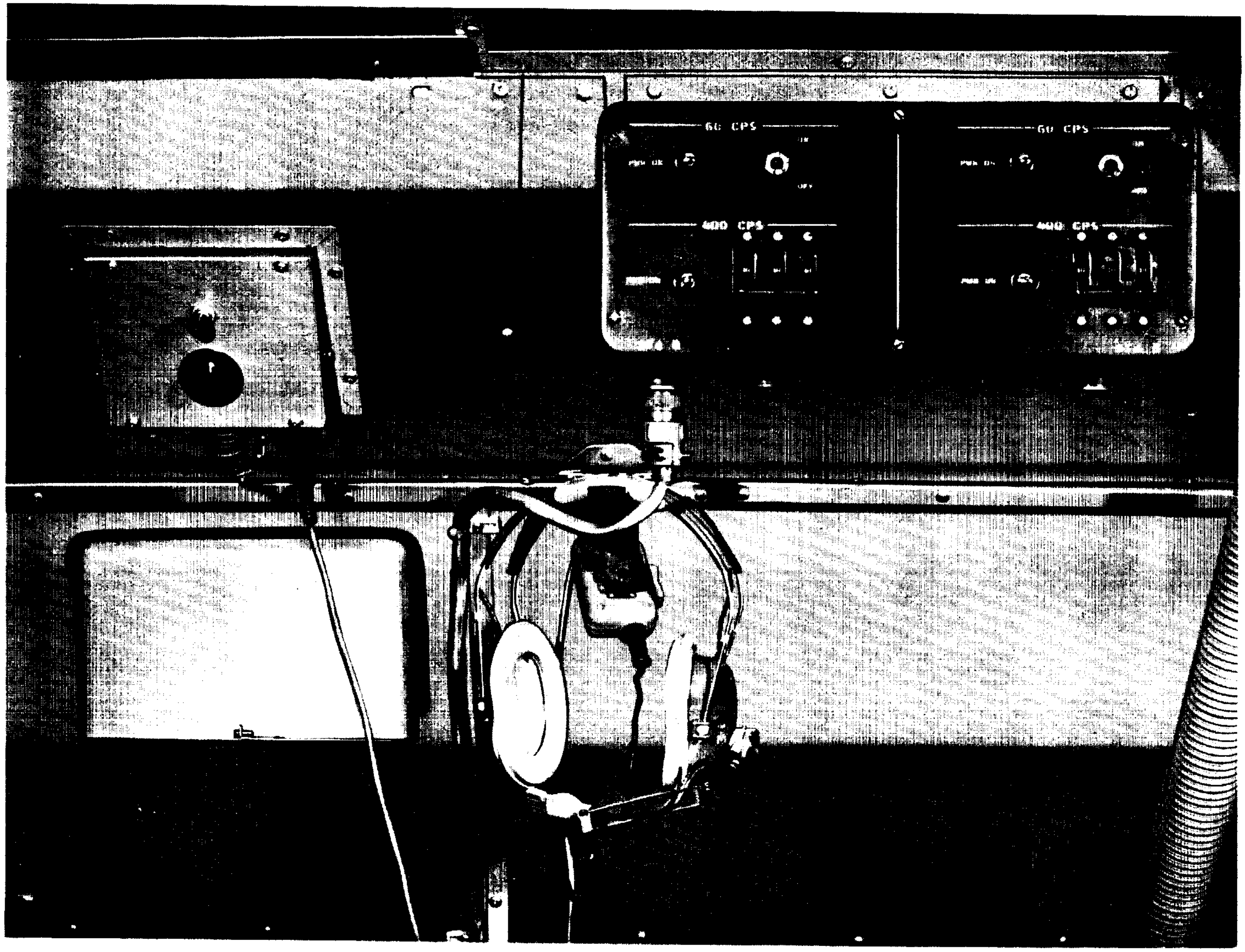
6.4.1 400 Hz power

Each 400 Hz outlet can supply 2.5 KVA of three-phase, four-wire, wye-connected power at 200 volts phase-to-phase. Single-phase, 115 volt, 400 Hz power can also be taken from this outlet; however, designation of the phase to be used must be made by the project manager at Ames so that as balanced a three-phase load as possible is put on the aircraft's system.

6.4.2 60 Hz power

The average amount of 60 Hz power available at each outlet is 600 watts. Each 60 Hz outlet can deliver up to 2 kilowatts, but not simultaneously to all outlets because of the limited source capacity (Section 6.1).

Thus, anyone who needs more than 600 watts of 60 Hz power must notify the Ames project manager well in advance of equipment installation so that adequate allotment of the available power may be made. An experimenter asking for an excessive share of the 60 Hz power may be asked to switch some of his equipment to 400 Hz power. It is recommended that anyone obtaining new electrical or electronic equipment for the 990 flights procure, preferentially, systems that operate on 400 Hz.



Typical electrical, interphone, and digital time signal outlets.

Figure 6.1 (Nov. 70)

SECTION 7

SPECIAL PORTS AND WINDOWS

7.1 General Description and Use

A number of special ports have been installed in the fuselage at various elevations and longitudinal locations. In addition, several of the standard passenger windows have been modified for special purpose use. These special ports and windows are intended primarily for the installation of optical quality glass; defrosting systems and safety features are provided.

All of the special ports and windows fall into one of the following classifications according to elevation in the fuselage: zenith, 65° elevation, 14° elevation, and nadir. The longitudinal location of these ports is shown in Figures 4.1 and 4.3. Typical cabin dimensions at a cross-section through the 65° elevation and the 14° elevation ports are given in Figure 4.2. The two zenith ports are located in the forward portion of the cabin (Fig. 4.1) where the air-conditioning duct has been rerouted.

Hardpoints for mounting equipment near windows are described in Section 5.2.3. Pertinent window dimensions are shown in Figures 7.1 through 7.4. Further specific information on these various ports is given in the following paragraphs.

7.2 Description of Special Ports

7.2.1 65° and zenith ports

There are thirteen 65° elevation ports and two zenith ports which provide a potential 12 x 14-inch clear aperture. The 12-inch dimension is along the longitudinal axis of the aircraft. The 65° openings are located on the port side of the aircraft (Figs. 4.1, 4.2). Figure 7.1 shows how these ports are installed in the aircraft structure and includes some pertinent dimensions. It is emphasized that the window-opening frame constitutes part of the basic aircraft structure and thus cannot be removed, drilled, or otherwise modified.

The ports are designed so that single-pane optical quality glass may be installed. Note that a sliding safety glass is provided for use when observations are not being made. Figure 7.3 shows the dimensions of the window-opening frame, the glass frame, and the optical glass. The optical glass is held in an aluminum frame by a silicon rubber gasket which is bonded to the frame (Fig. 7.3). Glass thicknesses up to 1.25 inches can be accommodated. All edges of the glass must be chamfered to minimize chances of chipping.

7.2.2 14° elevation ports

Nine passenger-type windows (14° elevation) have been modified to accept optical glass as shown in Figure 7.2. These windows have also been provided with sliding safety glass and defrosting ducts. Dimensions of the glass and frames for these ports are included in Figure 7.3.

7.2.3 Nadir ports

Six nadir ports have been installed in the fore and aft cargo areas (Fig. 4.3). The window opening dimensions are included in this figure, and the glass and glass frame dimensions are listed in Figure 7.3. The dimensions of the two forward nadir ports are identical to those for the 65° and zenith ports. However, none of the nadir windows have been provided with inboard sliding safety glass.

7.3 Standard Passenger Windows

Standard passenger windows are installed between nearly all belt frames on both sides of the fuselage (Figs. 4.1, 4.2). These windows are double-pane Plexiglas with an additional anacoustic Plexiglas pane on the inside of the cabin (Fig. 7.4). The anacoustic pane can be removed to permit observation through the outer panes only. However, this must be done on the ground by an aircraft crewman. Typical transmission curves for these windows are given in Figure 7.5.

7.4 Optical Materials of Non-standard Sizes

Windows of other than the standard sizes given in Figure 7.3 may be installed by fabricating special adapters which have the outside dimensions of the standard glass frame. Figure 7.6 gives minimum safe sizes for various window materials. A typical installation of this type is shown in Figure 7.7. All aluminum parts of such assemblies should be sand blasted and black-anodized to minimize reflections.

It is imperative that glass be isolated from metal adapters by silicon-rubber gaskets and that the tolerance between the glass and adapter be sufficient to prevent strain on the glass due to thermal effects. In addition, all edges of the glass should be chamfered to prevent chipping of the glass or damage to the gasket. Under no circumstance will glass with a scratch or large unsmoothed chip be installed on the aircraft.

7.5 Special Purpose Window Inserts

Metal plates may be installed in any of the special ports to support experimental equipment either internally or externally to the aircraft. These inserts must be sized to replace the glass frame (Fig. 7.3).

The loads which such inserts can support without attachment to aircraft hardpoints are very limited. All such installations are considered individually and must be discussed with Ames personnel during preliminary planning (see Section 5.2.3).

7.6 Environmental Testing of Optical Windows

Each window assembly (i.e., complete with frame and gasket) is subjected to the following tests prior to installation aboard the aircraft. First, the assembly is subjected to a pressure differential of 27 lb/in^2 at room temperature for five minutes to check the pressure seal. Then, the assembly is subjected simultaneously to a pressure differential of 19.2 lb/in^2 and to a temperature differential of 160°F for 20 minutes to check the structural integrity. The pressure and temperature conditions are then rapidly reduced to ambient room values.

To allow adequate time for testing, window assemblies should be at Ames at least six weeks prior to the scheduled installation date.

7.7 Inboard Window Contamination

7.7.1 Anti-frost system

Because of the low outside temperature at operating altitude, cabin moisture may condense on the inside surface of single-pane windows. To prevent this, warm air supplied by the cabin air-conditioner is blown across the window. This is illustrated in Figure 7.8 for the 65° ports. A manually-operated butterfly valve in the duct to each port permits individual control of the air flow rate. The exit air temperature at full flow is approximately 72°F while the inner window surface is at approximately 64°F under extreme outside ambient conditions. Full flow is generally not required to keep the windows clear of condensation.

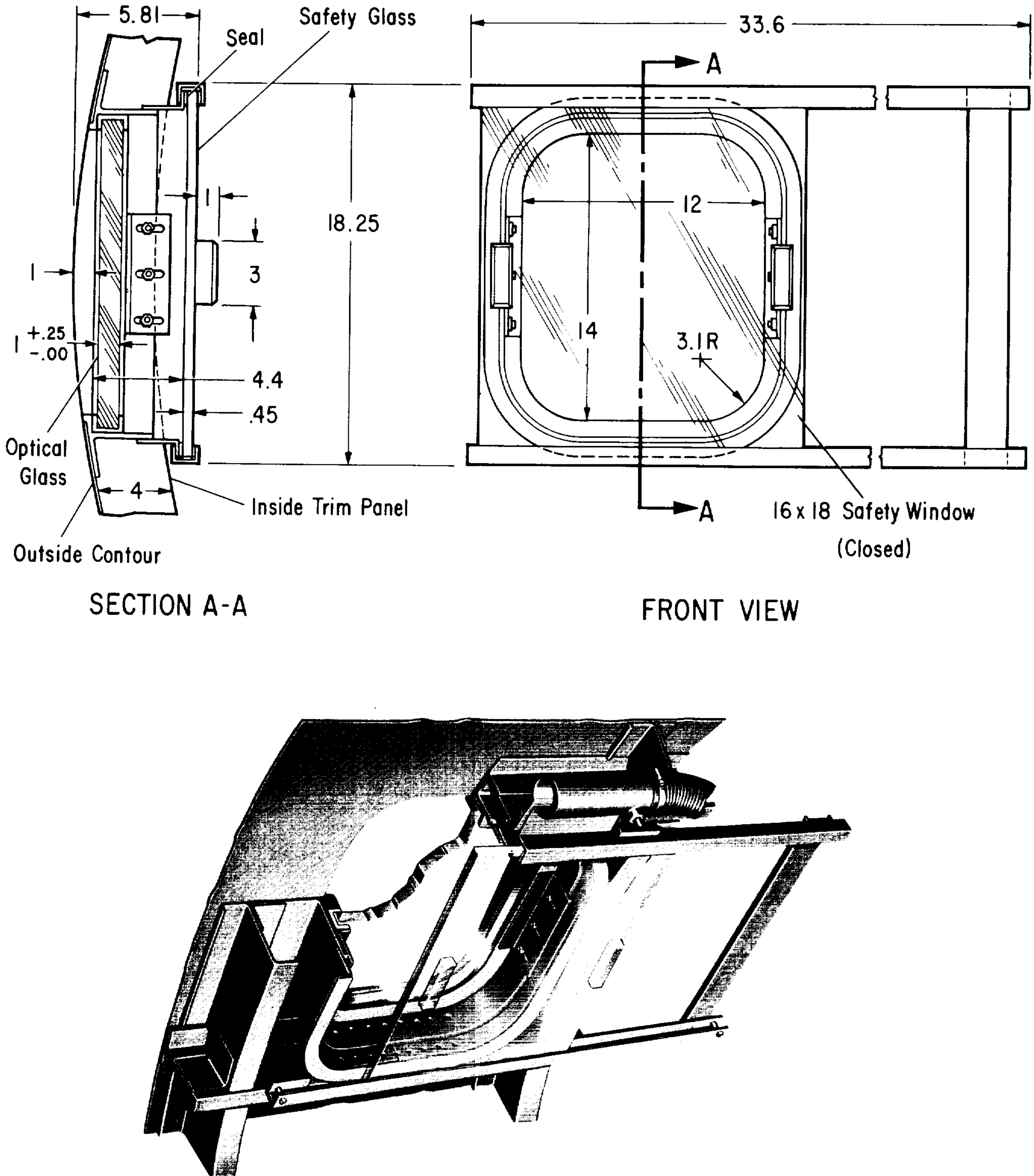
7.7.2 Oil contamination

A trace of engine oil vapor is often present in the air-conditioning duct, especially when the system is first activated. A satisfactory air filtering system has not yet been found. However, a satisfactory remedy, albeit somewhat inconvenient, is to cover the inside surface of the window with paper until observation time. Such protective covering can be removed for periods of one to two hours during which no significant deposit of oil is formed. In any event, the inside surfaces of the windows are readily accessible and can be cleaned in flight.

7.8 Outside Window Covers

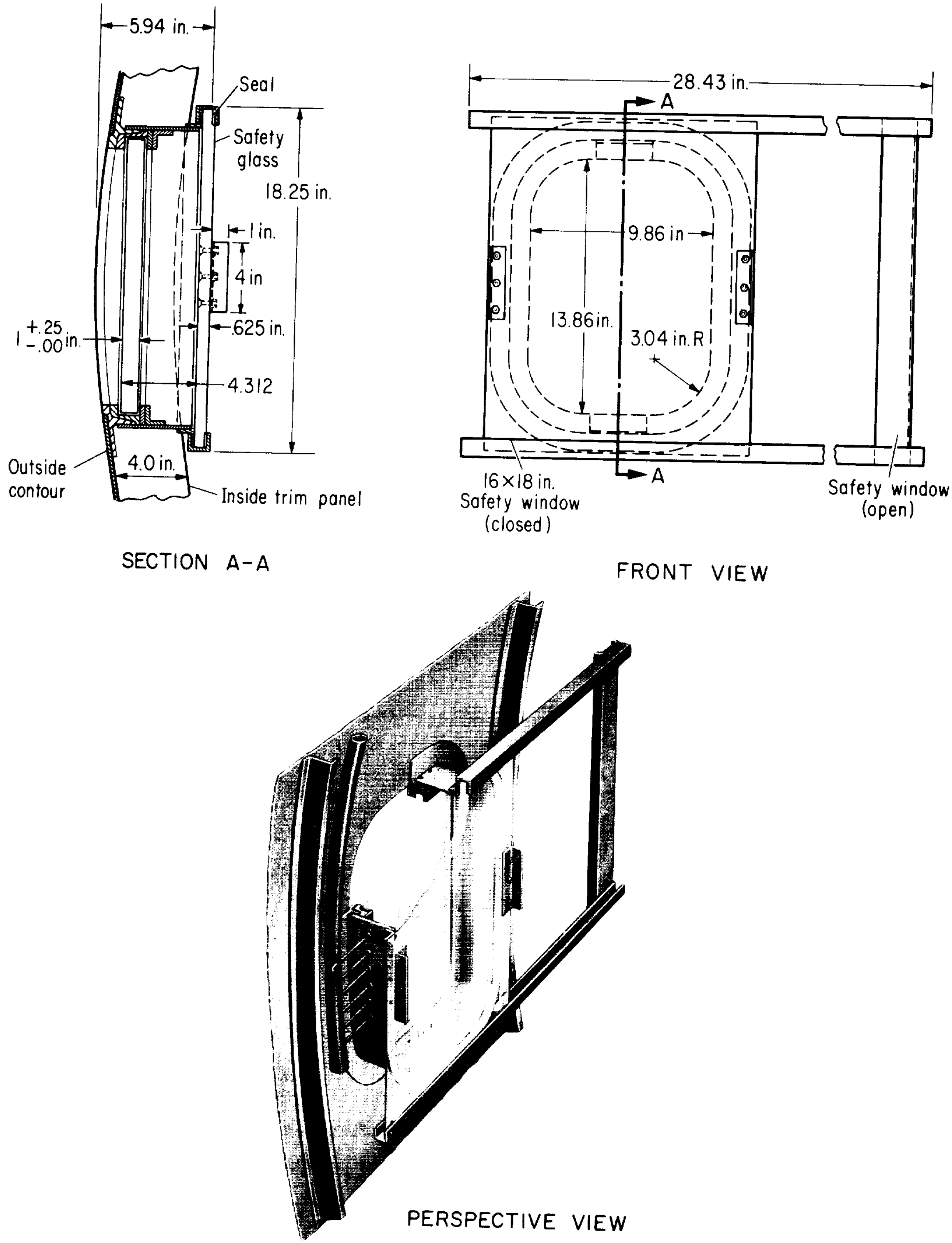
All of the nadir windows and seven of the 65° elevation windows have sliding shutters for protection of the external surface of optical windows (see Figs. 4.1 and 7.9). The shutters on the 65° windows are pneumatically sealed. These shutters can be cranked out of the field of view in flight. The remaining optical ports can be kept clean while on the ground by taping plastic sheets over the windows.

All dimensions in inches



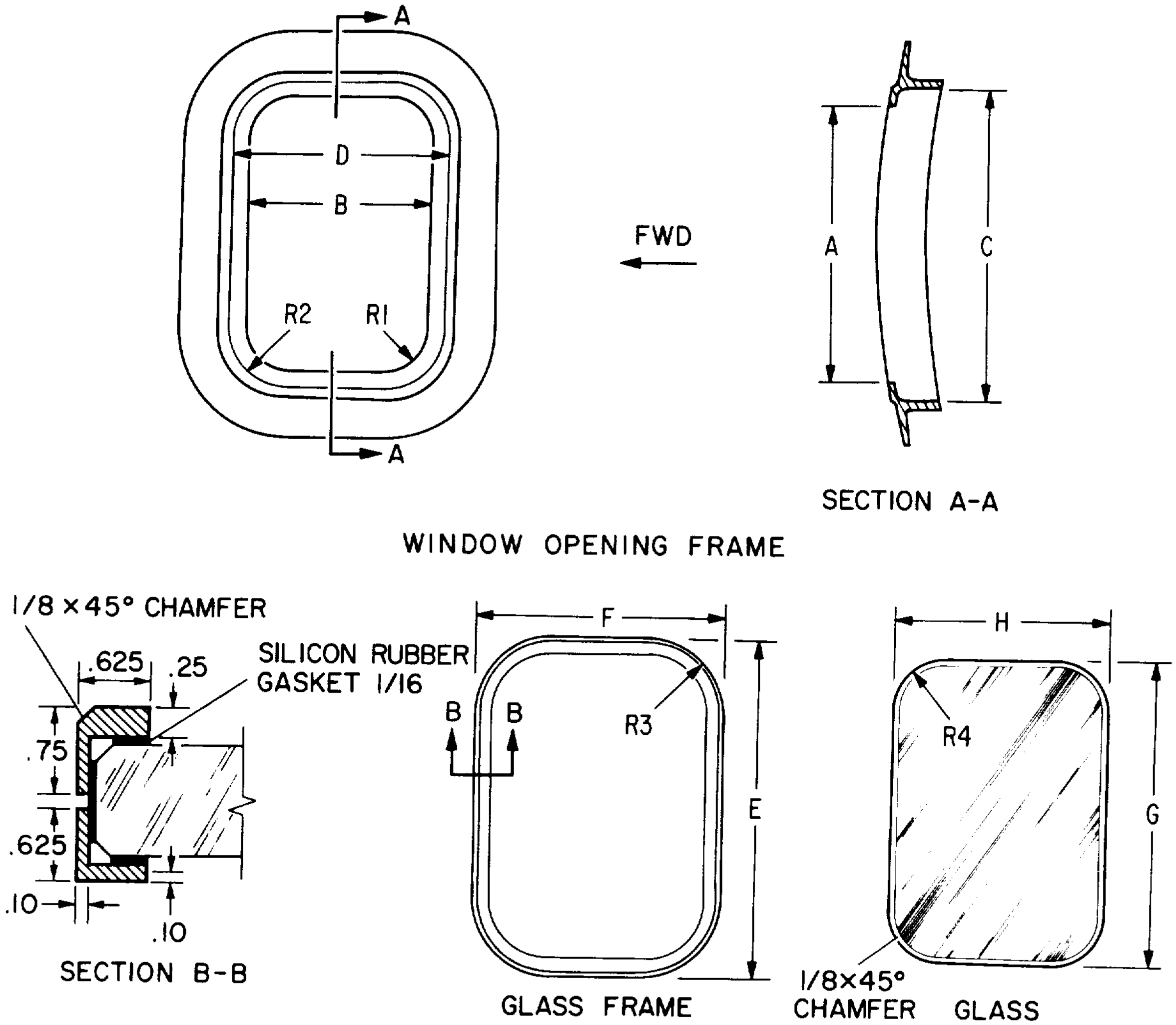
65° elevation and zenith ports and safety windows.

Figure 7.1 (Nov. 70)



14° elevation ports and safety windows.

Figure 7.2 (Nov. 70)



WINDOW LOCATION	A	B	C	D	E	F	G	H	R1	R2	R3	R4
65° & ZENITH	14	12	15.62	13.62	15.3	13.3	15	13	3.10	3.91	3.75	3.60
14°	13.86	9.86	15.58	11.58	15.10	11.10	14.87	10.87	3.10	3.82	3.66	3.55
NADIR[2]	13	11	14.62	12.62	14.3	12.3	14	12	3.10	3.91	3.75	3.60

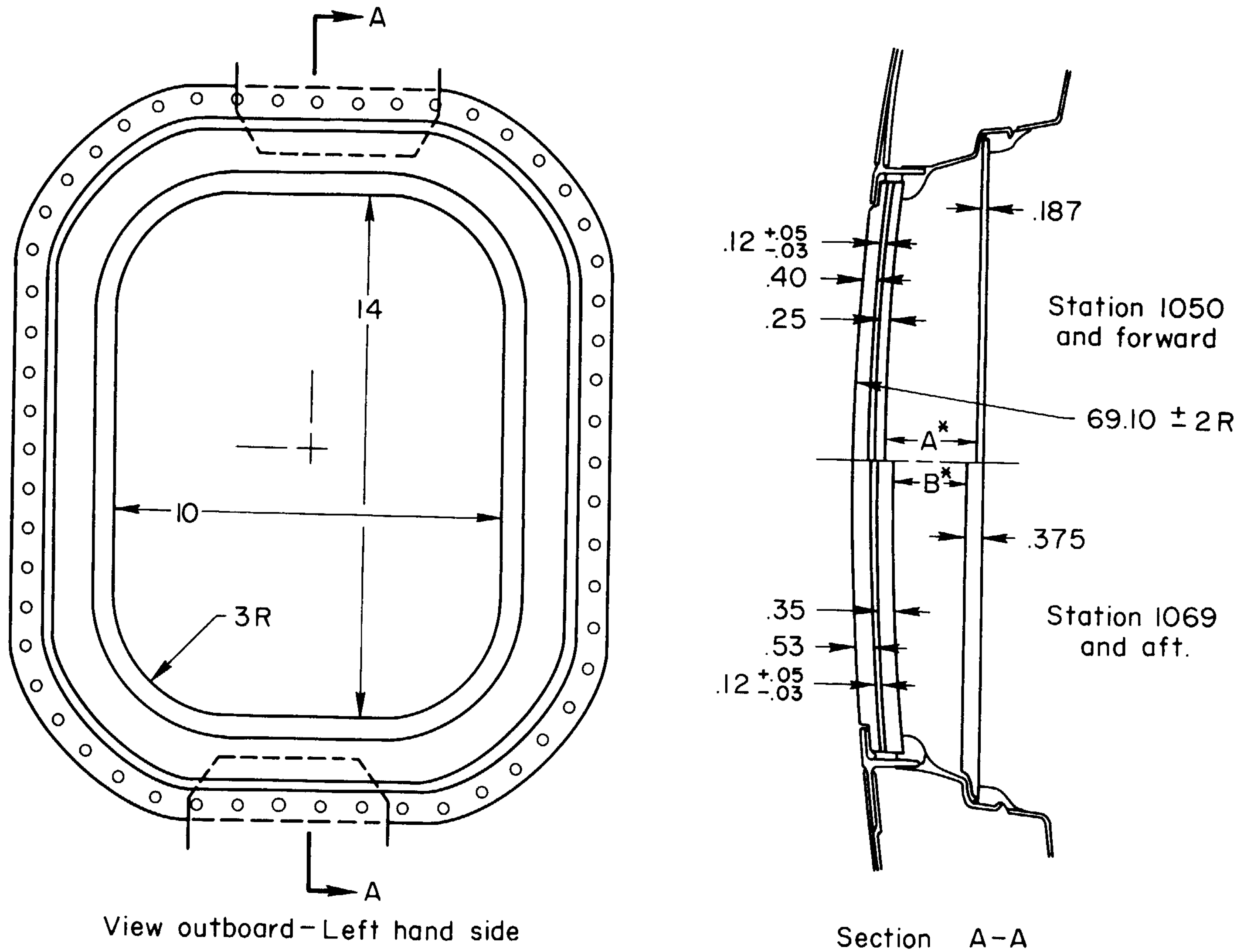
All dimensions in inches

Notes:

1. Tolerance on all dimensions ± 0.030 inch
2. Dimensions of 2 forward nadir ports same as 65° ports
3. For blank plates use same dimensions as glass frames

Glass and frame dimensions for optical windows.

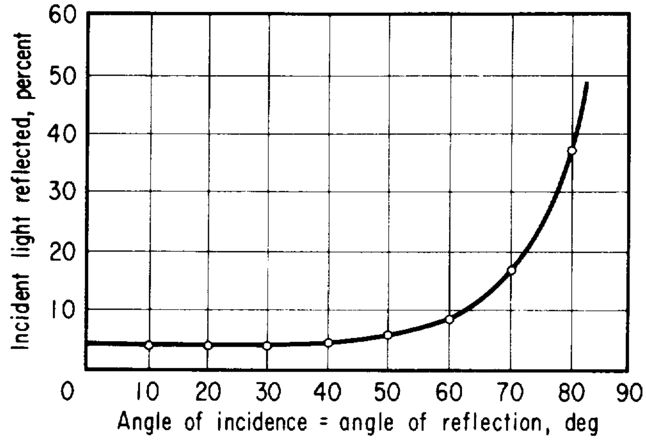
Figure 7.3 (Nov. 70)



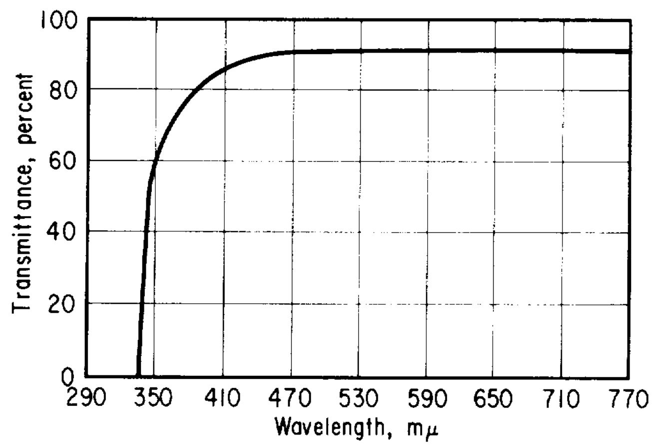
A* = 2.125 (At center line) B* = 1.750 (At center line) All dimensions in inches

Standard passenger windows.

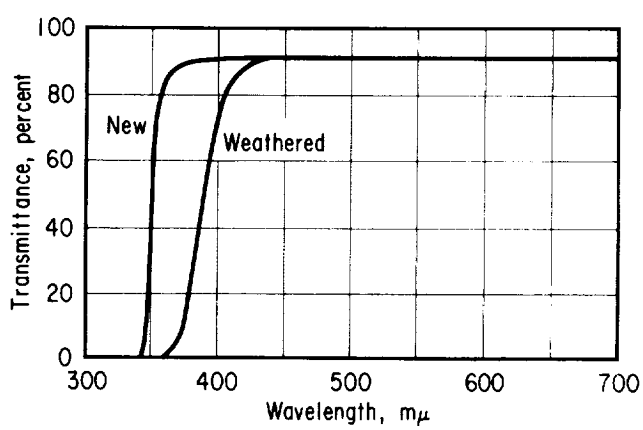
Figure 7.4 (Nov. 70)



REFLECTION FROM PLEXIGLAS FOR UNPOLARIZED LIGHT



TRANSMITTANCE OF OUTER (DOUBLE) PANE



TRANSMITTANCE OF INNER PANE

Optical characteristics of standard passenger windows.

Figure 7.5 (Nov. 70)

MATERIAL	DIMENSIONS (Inches)		
	Outside diameter	Clear aperture diameter	Minimum thickness
Soda-lime, Borosilicate Crown, Quartz, Fused Silica, or Cervit	1.5	1	0.1
	2.5	2	0.2
	4.75	4	0.4
	6.75	6	0.6
	9	8	0.8
	11	10	1.0
	13	12	1.0
Arsenic Trisulfide, Calcium Fluoride, Ruby, Irtran, Polyethylene, Polypropylene, etc.	2	1	0.2
	3	2	0.3
	5.5	4	0.5
	7.5	6	0.7
	9.5	8	0.9

NOTES: a) The above are minimum thicknesses. Greater thicknesses are allowable up to the space available in the port system; in general, the maximum thickness that can be accommodated is 1.25 inches.

b) For non-circular windows, the minimum thickness is governed by the largest diagonal dimension.

Minimum thicknesses of window materials.

Figure 7.6 (Nov. 70)

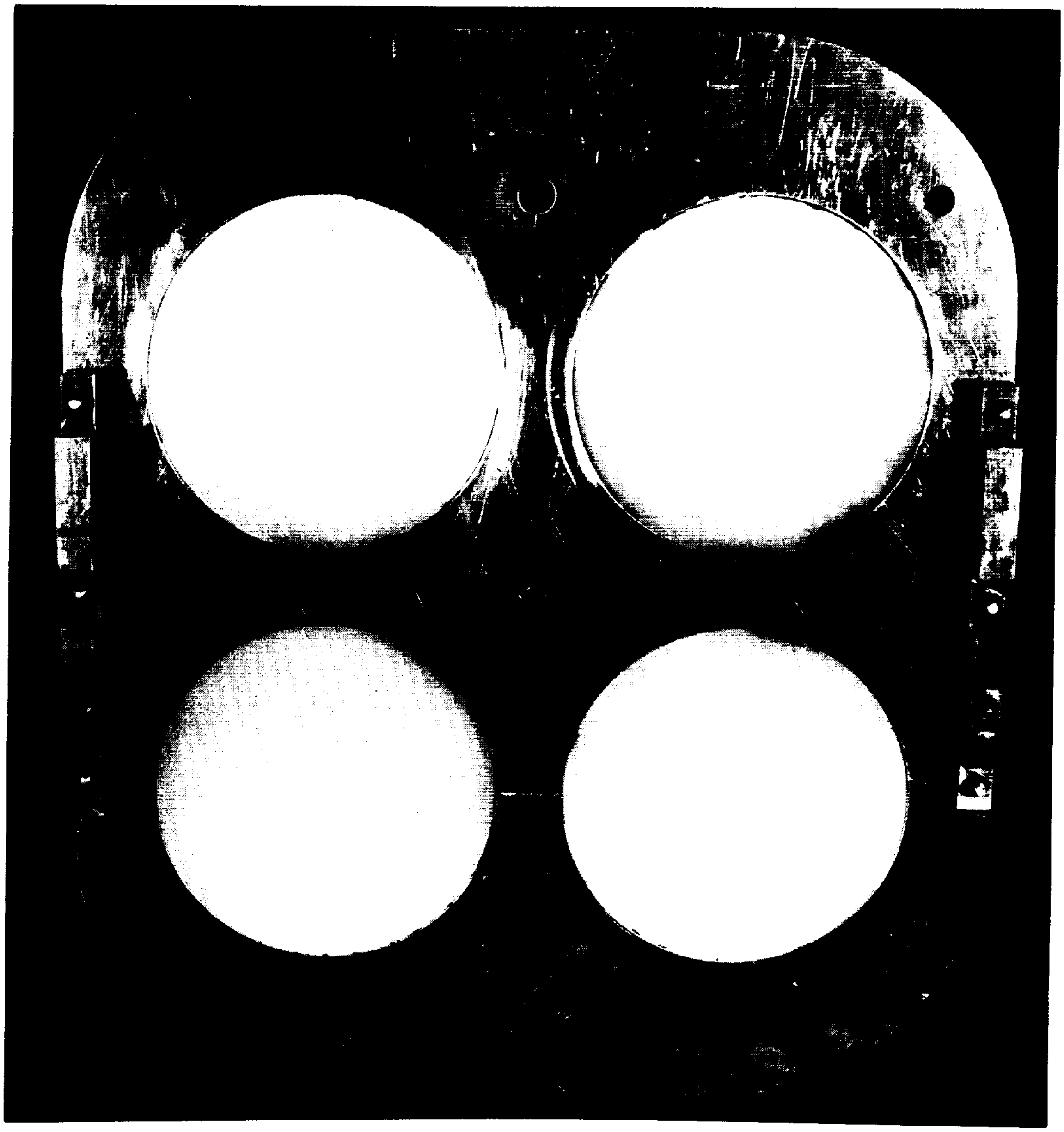
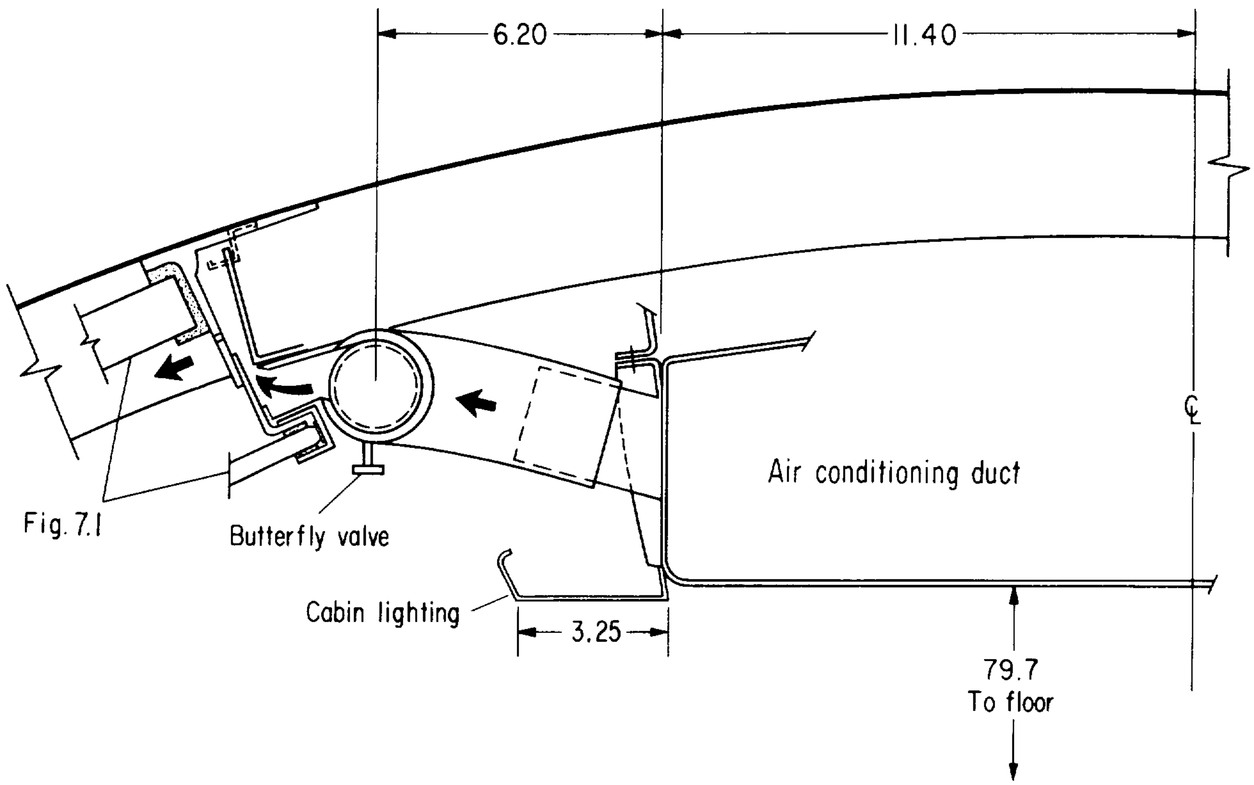


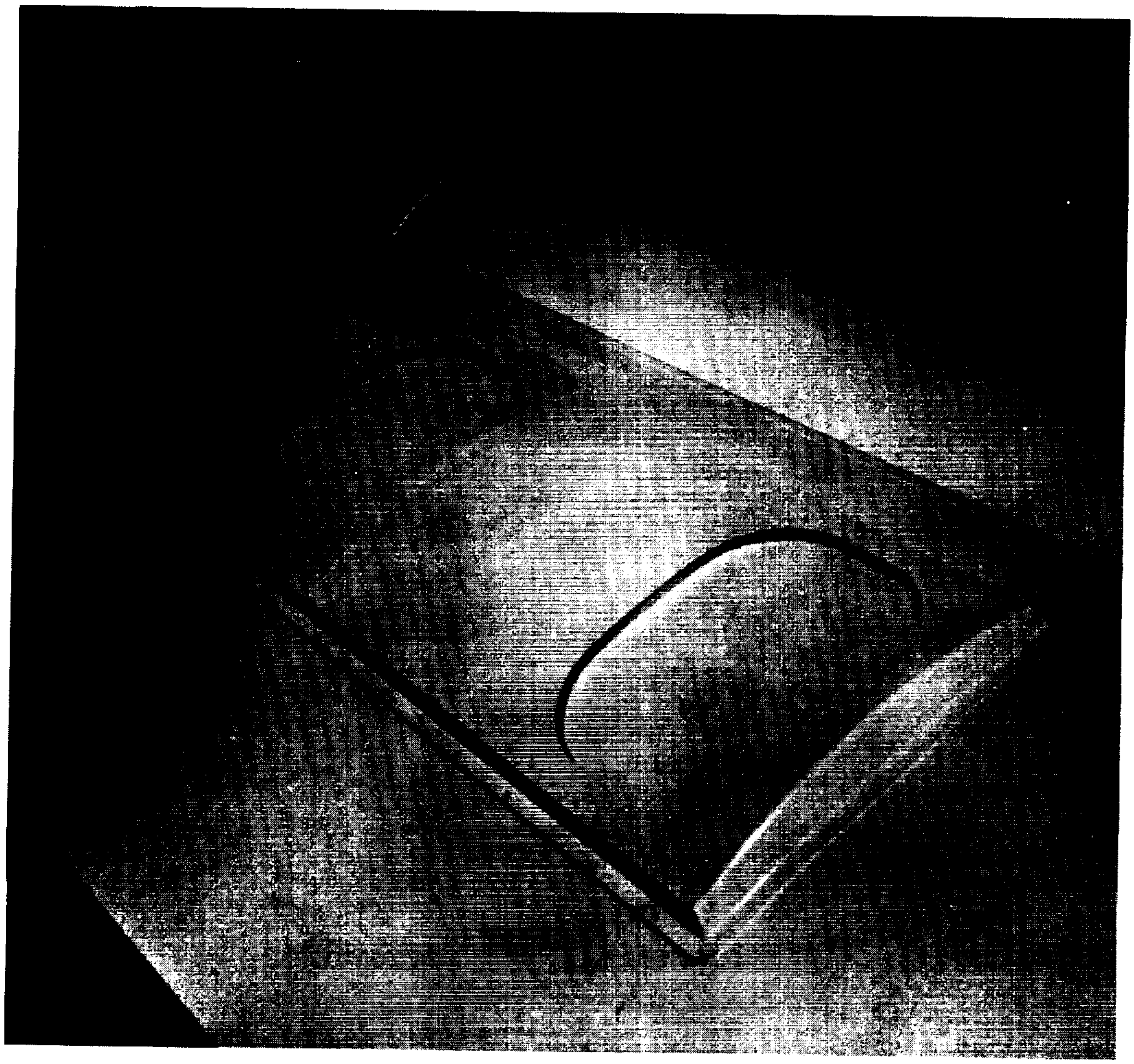
Illustration of special window mounting: four 5-inch diameter polypropylene windows in a modified blank-out plate.

Figure 7.7 (Nov. 70)



Cabin air-conditioning duct and defrosting system.

Figure 7.8 (Nov. 70)



Outside shutters on 65° elevation windows.

Figure 7.9 (Nov. 70)

SECTION 8

TIMING INFORMATION

Two time code generators (Astrodata Model 6190 and Chrono-Log Model 20,001) are available for use aboard the aircraft. Generally, only one of these units is installed for a given mission. They provide both a visual display (nixie) of the time of day and a variety of electrical time codes and timing pulses which can be distributed to experimental stations. To prevent the feedback of spurious signals and to provide more load capacity, buffering units and amplifiers have been installed in the time code distribution system.

The time code generator clock is synchronized with time signals broadcast from NBS radio WWV or equivalent stations throughout the world. The outputs available from these two generators and the time code distribution system are described below.

8.1 The Astrodata Model 6190 Time Code Generator (TCG)

The internal frequency standard of this TCG is a 1 MHz crystal oscillator which has a stability (aging rate) of 5 parts in 10^9 per day. The equivalent time error is less than 0.1 millisecond per day. Both serial (sequential) and parallel outputs for time-of-day codes as well as timing pulses at various frequencies are available. Figure 8.1 summarizes the time-of-day codes and Figure 8.2 lists the timing pulse rates.

8.1.1 The IRIG B serial output code

The IRIG B dc level shift code is illustrated in Figure 8.3. The code consists of 100 width-modulated pulses within a 1 second time frame. A reference marker indicates the beginning of the time frame, and the coded time is the time at the beginning (leading edge) of this reference marker. Reference markers P_0, P_1, . . . , etc., within the time frame serve to separate the subcode words for seconds, minutes, hours, and days as well as to aid in interpolation of time within the frame. The code is in binary-coded-decimal (BCD) form (1,2,4,8) for units of seconds, tens of seconds, units of minutes, tens of minutes, and so on. To read the code, all the binary one pulses are counted and all the zero pulses are disregarded. The technique can be illustrated by considering the series of pulses representing days in Figure 8.3. For units of days, the 1 and 2 pulses are binary ones for a total of three days. For ten days, the 10, 20, and 40 are binary ones for a total of seventy days. For hundreds of days, only the 100 is a binary one. The total number of days is thus 3 days + 70 days + 100 days = 173 days. The technique for reading the subcodes for seconds, minutes, and hours is the same. The control functions are generally used for identifying the flight number. Following the control functions, the time frame is completed by a series of index markers and reference pulses.

The modulated IRIG B time code is identical to the dc level shift code except that the pulses are formed by amplitude modulation of a 1 KHz carrier signal. A typical modulated pulse is illustrated in Figure 8.3.

8.1.2 The special serial codes (Type B)

There are 9 special serial codes (designated Rates 1 thru 9, Figure 8.1) available from the Astrodata TCG in either a dc level shift or a bi-level pulse format. The principal difference between the two types of codes is the amplitude modulation of the code pulses. The format for the bi-level code is illustrated in Figure 8.4. The code is composed of a Reference Marker and five subcode words of seconds, minutes, hours, days, and an identification word. Each subcode word is displayed in binary-coded-decimal form (1,2,4,8). The leading edge of all pulses is spaced at even increments in the code frame. The coded time refers to the leading edge of the reference marker. One pulse is deleted at the beginning and at the end of the time code word and between each digit in a code word. Index markers complete the time frame after the time of year and the identification word.

Examples of strip-chart recordings of the IRIG B and special serial codes (Type B) are presented in Figure 8.5. Only one rate is illustrated for the special serial codes since they differ only by the length of the code time frame.

8.1.3 The parallel outputs

Two types of parallel outputs are available from the Astrodata TCG. One is a parallel BCD (1,2,4,8) output which has 30 lines to provide 9 digits for seconds, minutes, hours, and days. The other parallel output is for driving nixie displays of time in days, hours, minutes, and seconds.

8.1.4 The timing pulses

The available timing pulses are listed in Figure 8.2, and a representative strip-chart recording is shown in Figure 8.6. The leading edge of the pulse is "on time." These pulse outputs are used primarily for driving marker pens on strip-chart recorders or for triggering cameras, solenoids, or other types of equipment.

8.2 The Chrono-Log Model 20,001 Time Code Generator (TCG)

The basic time-of-day code for the Chrono-Log TCG is the NASA 36-bit BCD for hours, minutes, and seconds. Day of the year and identification words are not available. As with the Astrodata TCG, the Chrono-Log TCG is generally used with the buffers and amplifiers in the time code distribution system. An internal 1 MHz oven-mounted crystal oscillator is used as the frequency standard. The oscillator is stable to within 1 part in 10^8 per day. Ambient temperature variations from 0°C to 55°C will shift the frequency less than 3×10^{-8}. If greater stability is required, an external 1 MHz frequency standard may be used.

Figure 8.7 lists the time-of-day codes and Figure 8.8 lists the timing pulses available from the Chrono-Log TCG.

8.2.1 The serial output codes

The serial graphic slow codes are designed primarily for use with paper chart recorders. The specifications for these codes are listed in Figure 8.7 and the code format is illustrated in Figure 8.9. The code pulses are in bi-level format (i.e., height and width modulated) and a reference marker indicates the beginning of each time frame. The leading edge of the reference marker is "on time."

The serial level shift code is similar to the Astrodata dc level shift codes. This code is used with paper chart recorders which have good frequency response and fast paper feed rates. The level shift code pulses are width modulated only--otherwise, the format is the same as for the slow codes (Fig. 8.9).

The serial modulated carrier time code is used primarily for recording on magnetic tape. The code format is identical to the slow code format except for the pulse modulation.

Examples of strip chart recordings of the Chrono-Log serial output codes are presented in Figure 8.10. Only one example of the slow code is included since the only essential difference is the length of the code frames.

8.2.2 The Chrono-Log parallel outputs

The NASA 36-bit BCD parallel code output is for magnetic tape recording of hours, minutes, seconds, milliseconds, and 0.1 milliseconds. The other parallel output is for driving remote nixie displays of hours, minutes, and seconds. Up to five remote nixie displays can be accommodated.

8.2.3 The Chrono-Log timing pulses

The Chrono-Log timing pulses are listed in Figure 8.8. Note that for the short pulses the leading edge of the pulse is "on time" and for the long pulses, the trailing edge is "on time." Figure 8.11 shows representative strip chart recordings of the short and long pulses.

8.3 The Time Code Distribution System

A timing information distribution system has been installed on the CV-990 to serve individual experimental stations. The high frequency receiver (normally to receive NBS radio WWV), the time code generator, and the buffering-amplifying system are mounted in a standard rack just aft of the forward cargo access hatch (Fig. 4.1). Figure 8.12 is a photograph of the control face of the system and Figure 8.13 shows the aft face which includes the patching panels. These patching panels provide for quick connection of the individual experimental stations with the desired outputs from the timing-amplifying system. In addition, to the timing signals, outputs from selected aircraft instruments are available at the patch panel for distribution to experimental stations. These outputs are described in Sect. 9. For distribution of the various signals, a number of co-axial cables (RG 58 U with BNC connectors) have been installed between the time code rack and the individual experimental stations (10 cables to each of 10 stations).

The buffering and amplifying system consists of an Astrodata Model 6620 Timing Terminal Unit and Sanborn Model 8875A differential amplifiers. These units are described below.

8.3.1 The Astrodata Model 6620 Timing Terminal Unit

The 6620 timing terminal unit serves as a buffer between the time code generator and the experimenter's station. It contains circuits which distribute, buffer, amplify, and otherwise condition the various signals generated by the TCG. The outputs available from this unit are as follows:

8.3.1.1 Relay driver

The relay driver has 7 separate units which provide a relay contact closure to ground for driving marker pens in strip chart recorders and galvanometers in oscillographs. Typically it is used with the dc shift serial time codes and the timing pulse outputs. The relay driver specifications are:

Output signal:	Contact closure
Code pulse rate:	100 PPS maximum
Contact rating:	300 volts maximum 3 amps maximum 25 volt-amp ac maximum 50 watts dc maximum
Signal delay:	< 4 ms relative to input
Input signal:	Normally 0 to -6 volts -4 volts closes relay

8.3.1.2 DC line keyer

The dc line keyer provides dc output signals suitable for driving marker pens in strip chart recorders and galvanometers in oscillographs. It is used primarily with the dc shift serial time codes and the timing pulse outputs. The line keyer specifications are:

Output signal:	0 to +12 volts adjustable
Experimenters load:	100 ohms to ground (max. load)
Code pulse rate:	up to 10^4 PPS
Rise and fall time:	< 10 μsec
Input signal:	0 to -6 volts

8.3.1.3 Dual line amplifier

The dual line amplifier is used to distribute amplitude-modulated time code signals to "FM" or "Direct Record" channels of magnetic tape recorders. The amplifier specifications are:

Frequency response:	±2 dB from 30 Hz to 30 MHz (referred to 1 KHz at 0/dBm output)
Signal output:	Adjustable 0 to 2.2 volts peak-to-peak into 600 ohm load for signal inputs 0.4 to 9.0 volts peak-to-peak
Gain:	15 dB maximum
Max. undistorted output:	15 volts peak-to-peak into 600 ohms at 1 KHz.
Output impedance:	Less than 150 ohms line-to-line, balanced, center-tapped

8.3.2 The Sanborn Model 8875A differential amplifier

The Hewlett Packard Sanborn Model 8875A is a wide-band, high-gain amplifier designed for millivolt-level dc or ac input signals. Ten of these units are available and they are typically used to amplify the signals from various aircraft instruments. They can also be used by experimenters to amplify low-level signals from experimental equipment. The differential design of the amplifier input circuit provides low drift and high rejection of common mode components. The output is suited for data acquisition systems employing digital voltmeters and printers, analog-to-digital converters, magnetic tape recorders, oscillographs, and strip chart recorders. A summary of the specifications is given below.

Bandwidth:	dc to 75 KHz within 3 dB
Gain:	1 to 1000 in 7 fixed steps (1, 3, 10, 30, 100, 300, 1000)
Input circuit:	Balanced differential; may be used single ended
Output circuit:	±10 volts, 100 milliamps

Type	Frame Length	Pulses Per Frame	Amplitude		Load Required	Type of Recorder
			"One"	"Zero"		
SERIAL OUTPUT:						
IRIG B, dc level shift	1 sec	100	–6 V	–6 V	>1000 ohms	"fast" paper chart
IRIG B, modulated 1 kHz carrier	1 sec	1000	–6 V	–6 V	>1000 ohms	magnetic tape
Special Serial Codes (Type B):						
Rates 1–9, dc level shift	as below	as below	–6 V	–6 V	>1000 ohms	paper chart
Rates 1–9, bi-level	as below	as below	+10 V	+6 V	>1000 ohms	paper chart
Rate 1	1 sec	50				
Rate 2	5 sec	50				
Rate 3	10 sec	50				
Rate 4	30 sec	60				
Rate 5	1 min	60				
Rate 6	5 min	60				
Rate 7	10 min	60				
Rate 8	30 min	60				
Rate 9	60 min	60				
PARALLEL OUTPUT:						
Parallel BCD, sec, min, hr, days	—	—	–6 V	0 V	>1000 ohms	magnetic tape
Nixie displays, seconds, minutes, hours, days (High-voltage Output (+270 V dc) is provided to drive the Nixie display)						

Astrodata Model 6190 time-of-day codes.

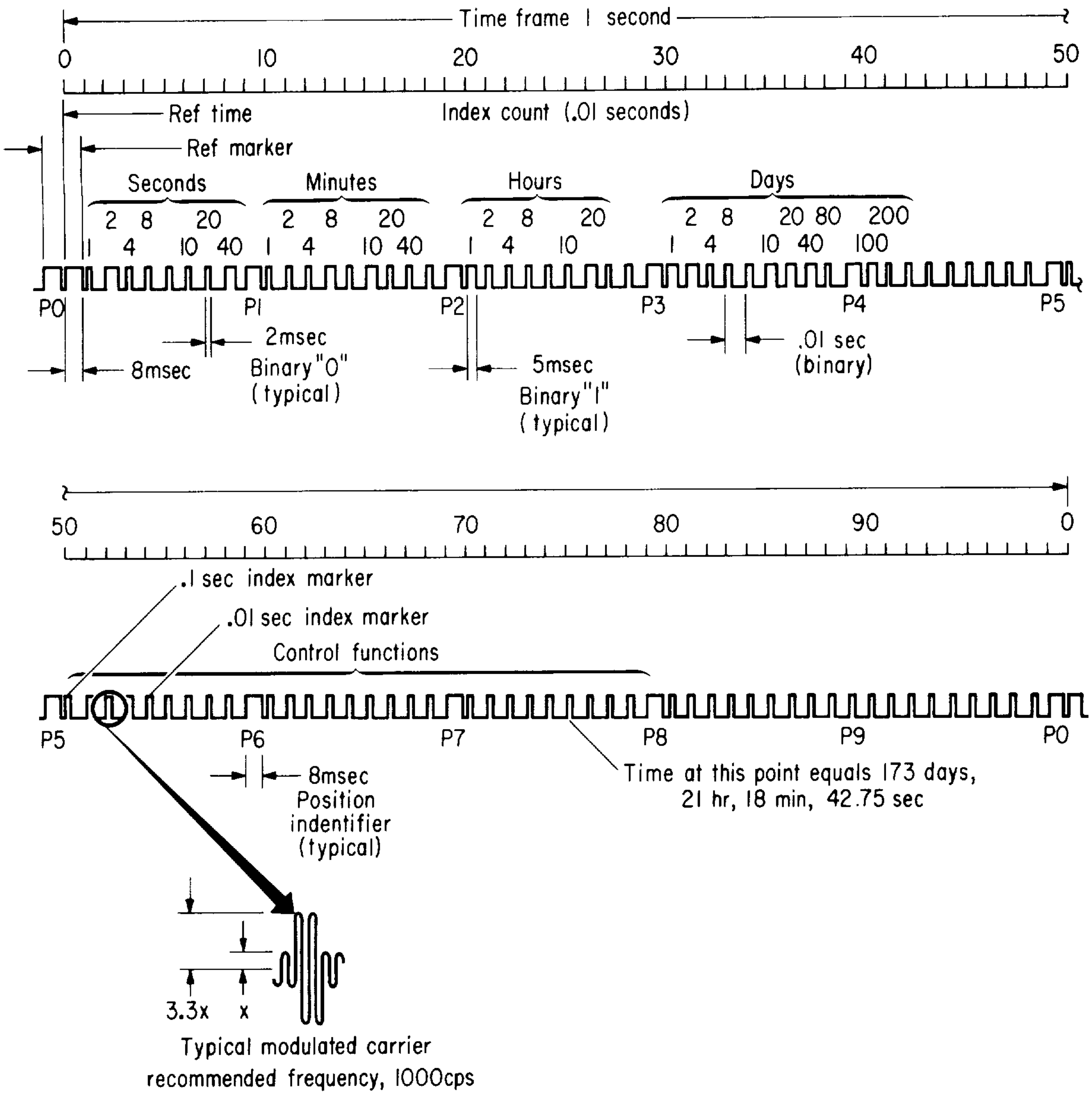
Figure 8.1 (Nov. 70)

Pulse Rate	Period	Amplitude	Duration	Rise Time
10^6 sec^{-1}	1 μs	6 V		$\leq 0.2\ \mu s$
10^5 sec^{-1}	10 μs	(from −6 V to 0 V)		
10^4 sec^{-1}	100 μs		10% of the	$<2\ \mu s$
10^3 sec^{-1}	1 ms		period	
10^2 sec^{-1}	10 ms			
10^1 sec^{-1}	100 ms			
→ 1 sec^{-1}	1 sec			
10^{-1} sec^{-1}	10 sec		8 sec	
20^{-1} sec^{-1}	20 sec		10 sec	
30^{-1} sec^{-1}	30 sec		20 sec	
→ 1 min^{-1}	1 min		40 sec	
10^{-1} min^{-1}	10 min		8 min	
1 hr^{-1}	1 hr		40 min	

Notes: 1. The leading, or positive-going edge is "on time".
2. → The arrows indicate the most commonly used outputs.

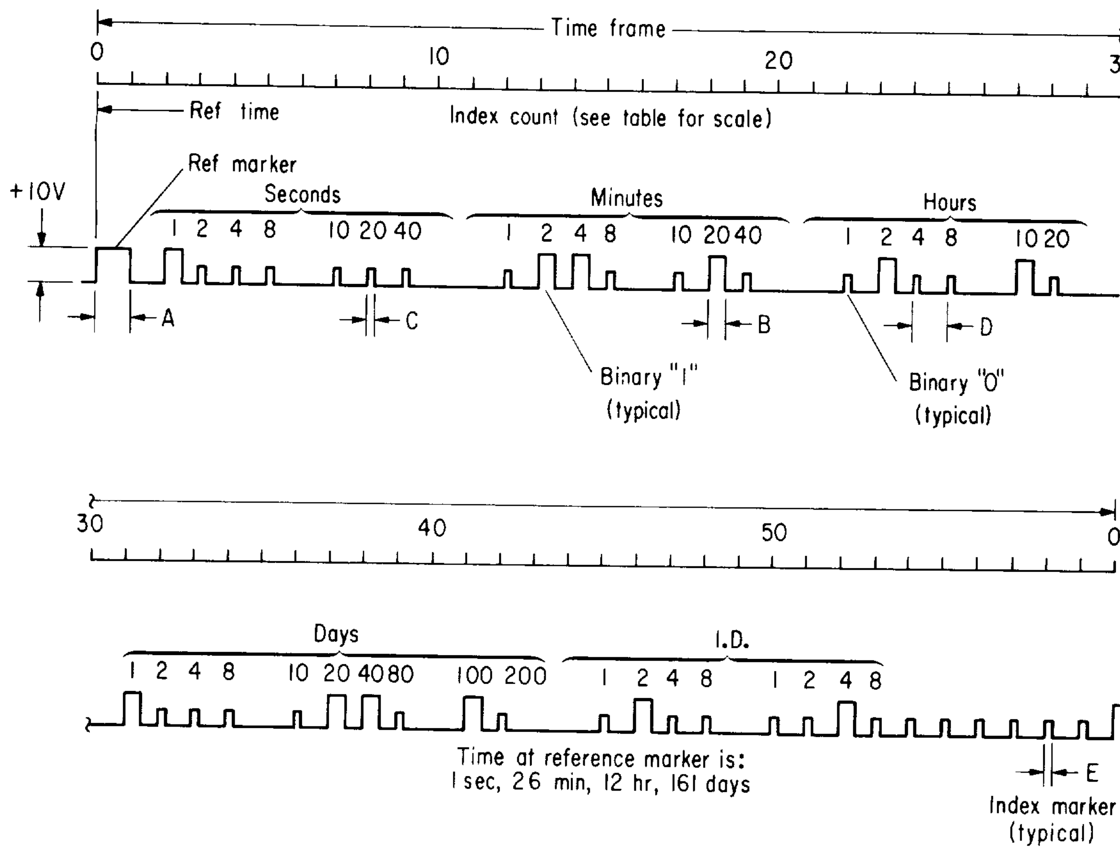
Astrodata Model 6190 timing pulses.

Figure 8.2 (Nov. 70)



The IRIG standard time code - Format 'B'.

Figure 8.3 (Nov. 70)

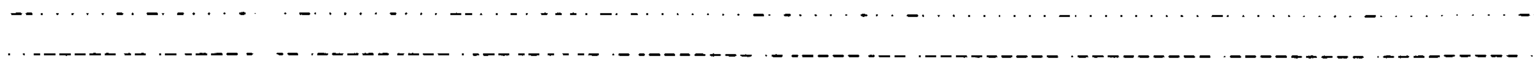


REFERENCE MARKER = 100% OF PERIOD
BINARY "1" = 50% OF PERIOD
BINARY "0" = 20% OF PERIOD
BINARY "1" AMPLITUDE = + 10V DC
BINARY "0" AMPLITUDE = + 6V DC

	PULSE RATE	TIME FRAME	D-PERIOD	A-WIDTH OF REF. MARKER	B-WIDTH OF BINARY ONE	C-WIDTH OF BINARY ZERO	E-WIDTH OF INDEX MARKER	NO. OF PULSES IN TIME FRAME
1	50 pps	1 sec	20 ms	20 ms	10 ms	4 ms	4 ms	50
2	10 pps	5 sec	100 ms	100 ms	50 ms	20 ms	20 ms	50
3	5 pps	10 sec	200 ms	200 ms	100 ms	40 ms	40 ms	50
4	2 pps	30 sec	½ sec	½ sec	250 ms	100 ms	100 ms	60
5	1 pps	60 sec	1 sec	1 sec	½ sec	200 ms	200 ms	60
6	1/5 pps	5 min	5 sec	5 sec	2½ sec	1 sec	1 sec	60
7	1/10 pps	10 min	10 sec	10 sec	5 sec	2 sec	2 sec	60
8	2 ppm	30 min	30 sec	30 sec	15 sec	6 sec	6 sec	60
9	1 ppm	60 min	60 sec	60 sec	30 sec	12 sec	12 sec	60

The Astrodata special serial codes - Type 'B'.

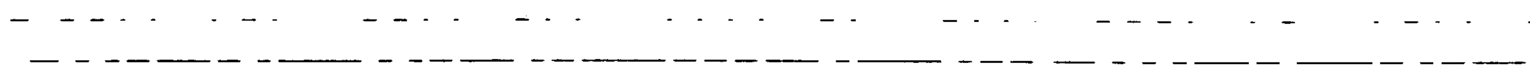
Figure 8.4 (Nov. 70)



t = 279d 10h 12m 24s

a) IRIG B - DC shift, paper drive 8 in/sec.

b) IRIG B - Modulated, paper drive 8 in/sec.

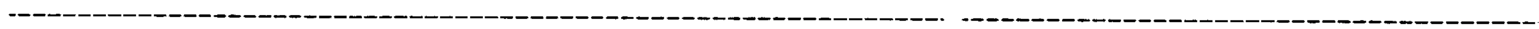


t = 271d 10h 13m 23s

c) Rate 2 - DC shift, paper drive 8 in/sec.

Examples of strip-chart recordings of the Astrodata time codes.

Figure 8.5 (Nov. 70)



a) 100 pps (8" in 1 sec.)

b) 10 pps (8" in 1 sec.)

Examples of strip-chart recording of Astrodata timing pulses.

Figure 8.6 (Nov. 70)

Type	Frame Length	Pulses Per Frame	Amplitude		Load Required	Type of Recorder
			"One"	"Zero"		
Serial graphic slow code	1 sec 5 sec 10 sec 0.5 min 5.0 min	50 50 50 30 30	10 V	6 V	≥1000 ohms	"slow" graphic or paper charts
Serial level shift	1 sec	100	−6 to −10 V	0 V	≥1000 ohms	"fast" graphic or paper, charts
Serial modulated carrier	1 sec	1000	10 V	3 V	500–700 ohms	magnetic tape
Parallel BCD, hours, minutes, seconds, milliseconds, 0.1 milliseconds	—	—	−6 to −10 V	0 V	≥5000 ohms	magnetic tape
Parallel Remote Nixie displays, hours, minutes, seconds	Signal level −200 Volts from a zero level 0 to +3 Volts					

The Chrono-Log TCG time-of-day codes.

Figure 8.7 (Nov. 70)

Short Pulses

The pulse occurs at the start of the time frame.

Pulse Rate	Amplitude	Load	Duration	Rise Time
1000 sec^{-1} 100 10 1	$\sim$8 Volts negative	$\geq$5000 ohms	$\sim 8 \times 10^{-6}$ sec	$\leq 1 \times 10^{-6}$ sec

Long Pulses

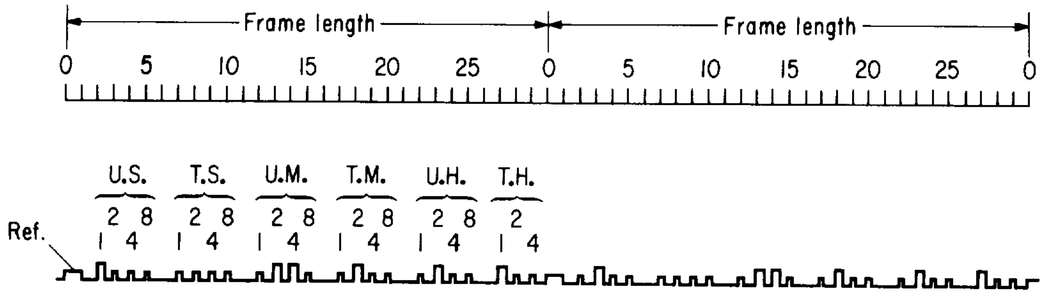
The end of the pulse coincides with the end of the time frame.

Pulse Rate	Amplitude	Load	Rise Time	Duration (3 Types Available)		
				"1-bit"	"4-bit"	"8-bit"
1000 sec^{-1} 100 10 1 0.1 sec^{-1} 1 min^{-1} 0.1 min^{-1} 1 hr^{-1}	−8 Volts or +10 Volts	$\geq$5000 ohms	$\leq 1 \times 10^{-6}$ sec	100% on alternates with 100% off	40% off 60% on	80% off 20% on

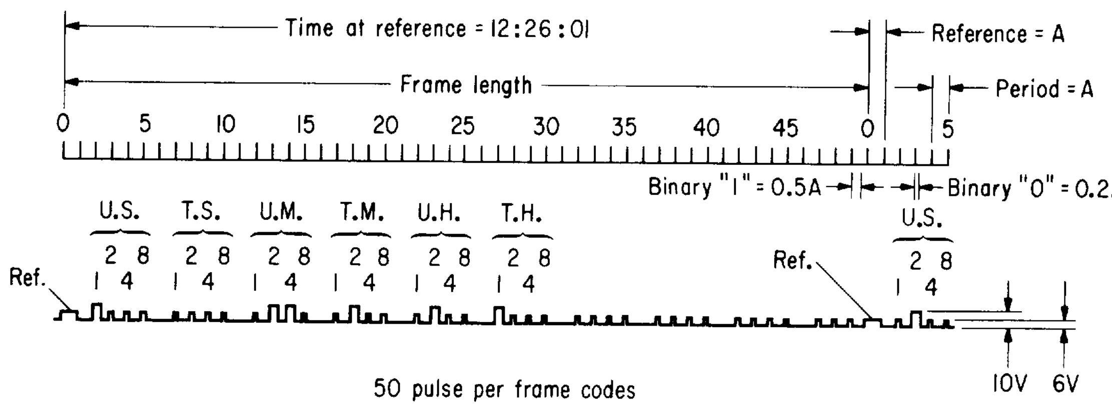
Any combination of pulse rate, polarity, and length can be supplied.

The Chrono-Log TCG pulse outputs.

Figure 8.8 (Nov. 70)



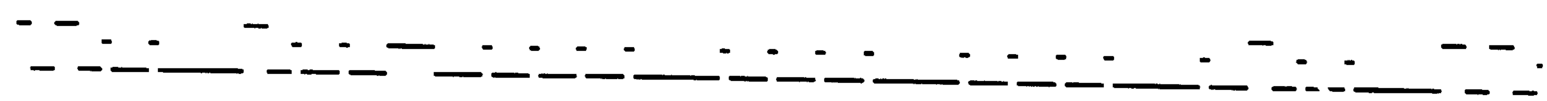
30 pulse per frame codes



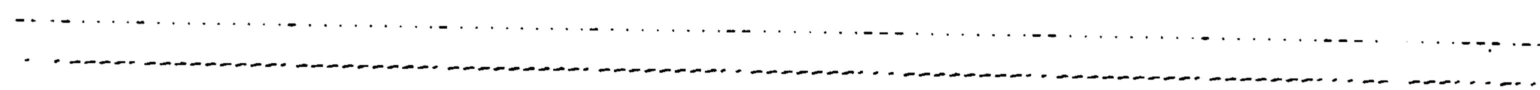
50 pulse per frame codes

Chrono-Log serial graphic slow code.

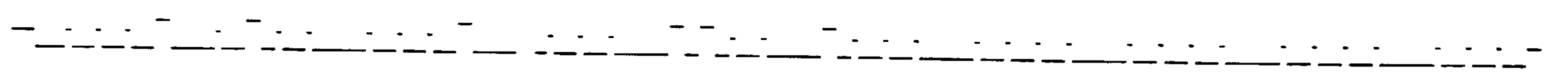
Figure 8.9 (Nov. 70)



a) Serial graphic slow code 30 pps - 0.5 min/frame



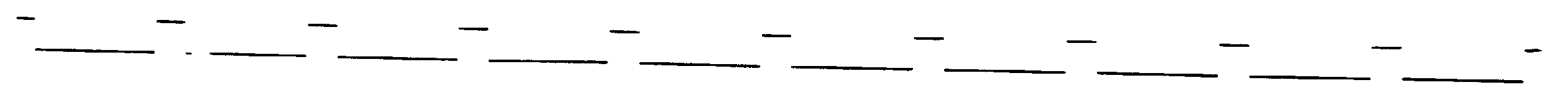
b) Serial level-shift code



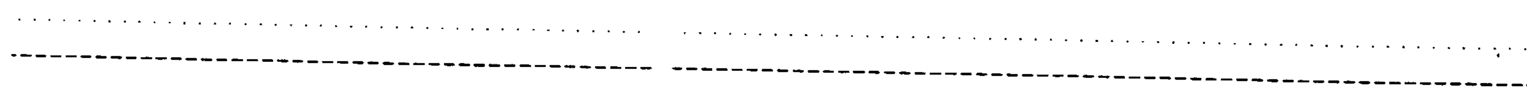
c) Serial modulated-carrier code

Example of strip-chart recordings of Chrono-Log time-of-day codes.

Figure 8.10 (Nov. 70)



a) Long pulse, 10 pps, 8 bit



b) Long pulse, 10 pps, 4 bit

Example chart recordings of Chrono-Log timing pulses.

Figure 8.11 (Nov. 70)

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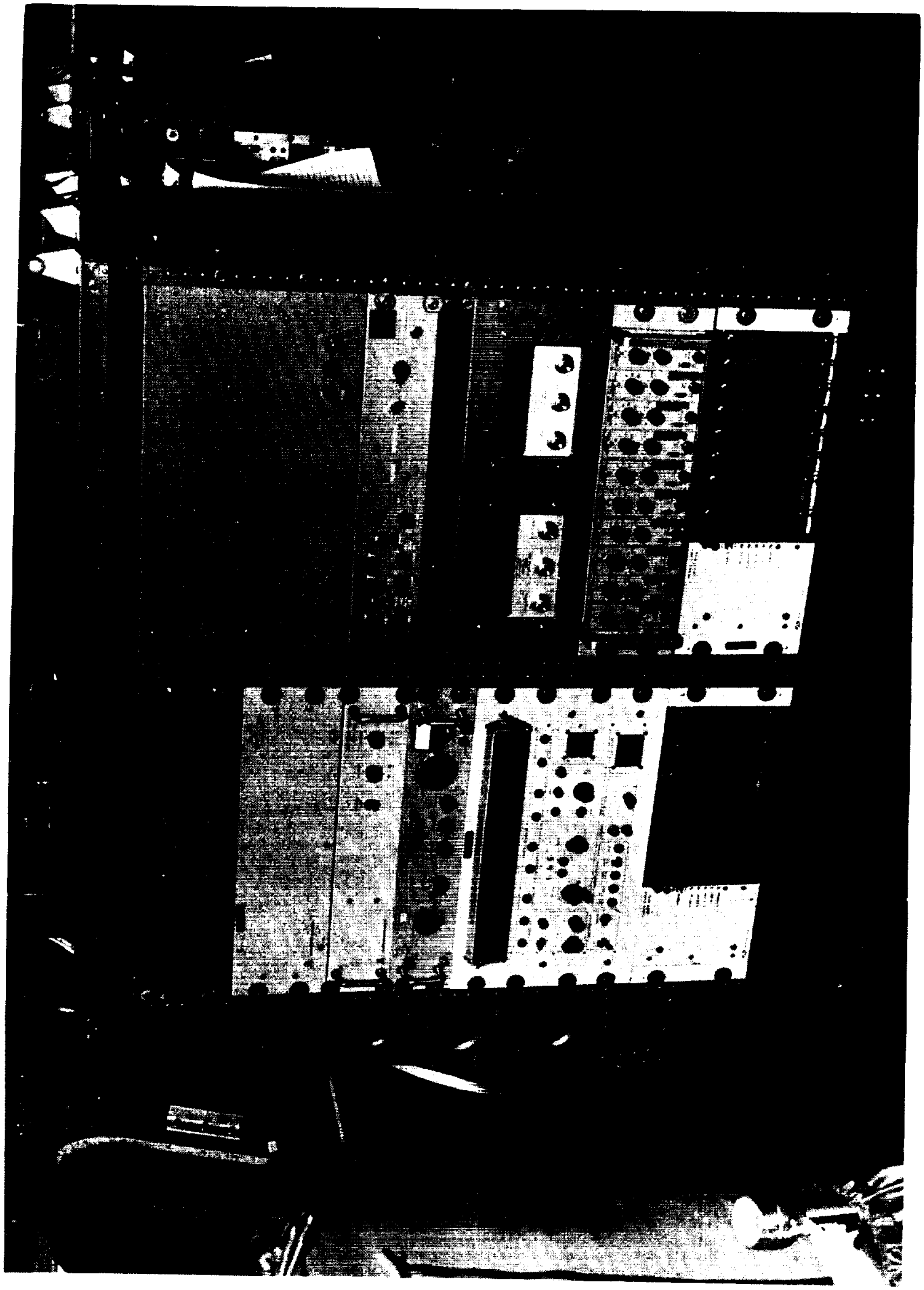
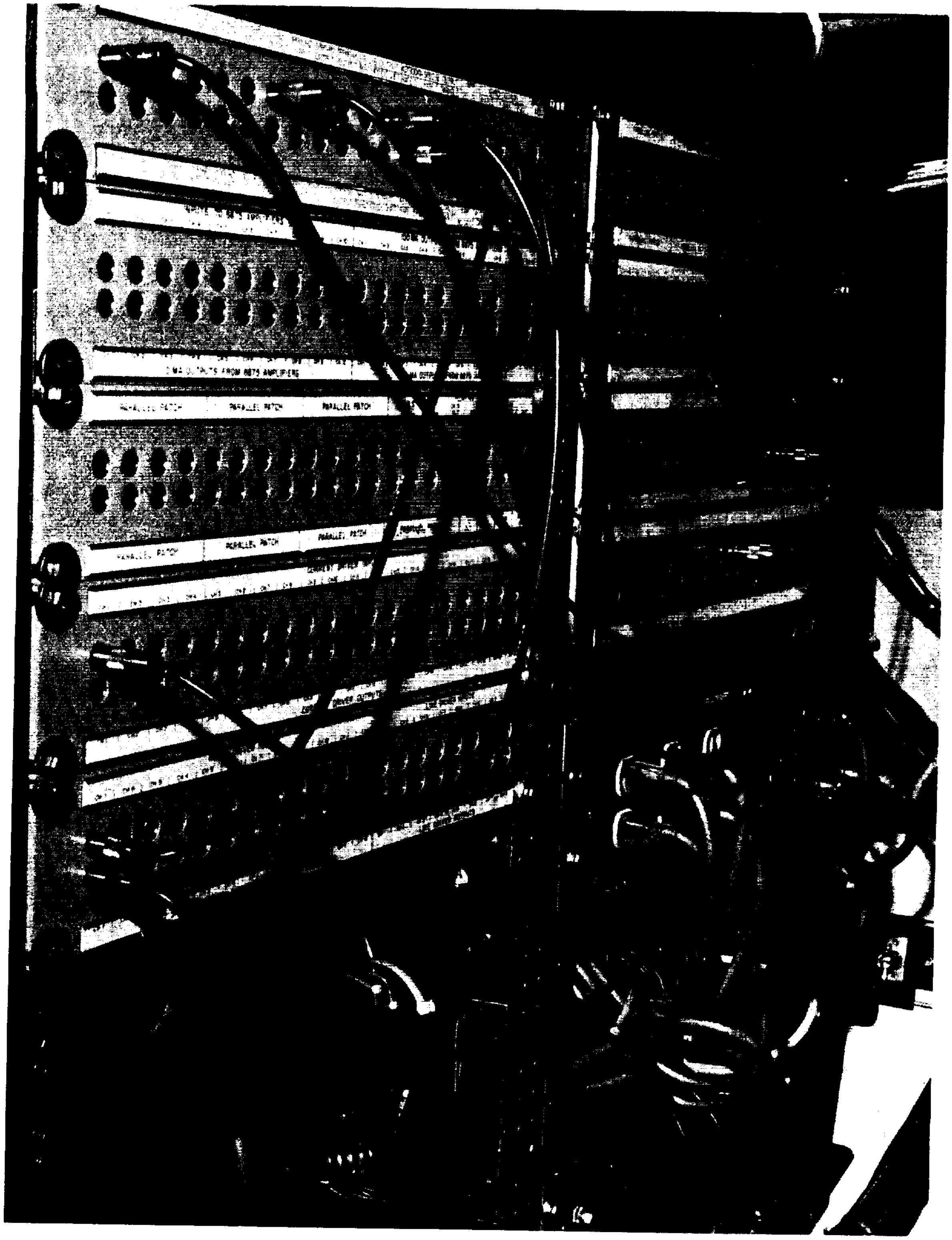


The CV-990 time-keeping rack.

Figure 8.12 (Nov. 70)



Aft face of time-keeping rack showing patch panels.

Figure 8.13 (Nov. 70)

SECTION 9

AIRCRAFT FLIGHT INSTRUMENT INFORMATION

9.1 Flight Instrument Outputs to Experimenters

In addition to the communication and navigation equipment described in Sect. 3, the aircraft is equipped with all of the standard flight instruments. The outputs from a selected number of these instruments have been connected to the patching panels on the timing information rack (see Sect. 8.3). These signals can be distributed to individual experimental stations through the Sanborn differential amplifiers (Sect. 8.3.2). The available outputs are:

Output	Signal Level
Static air temperature	0-10 Vdc
Total air temperature	0-10 Vdc
True air speed	0-10 Vdc
Pressure altitude	0-5 Vdc
Radar altitude	0-9 Vdc
Pitch and roll	±10 Vdc

SECTION 10

GYROSTABILIZED DEVICES

10.1 Gyro-Controlled Image Stabilizers

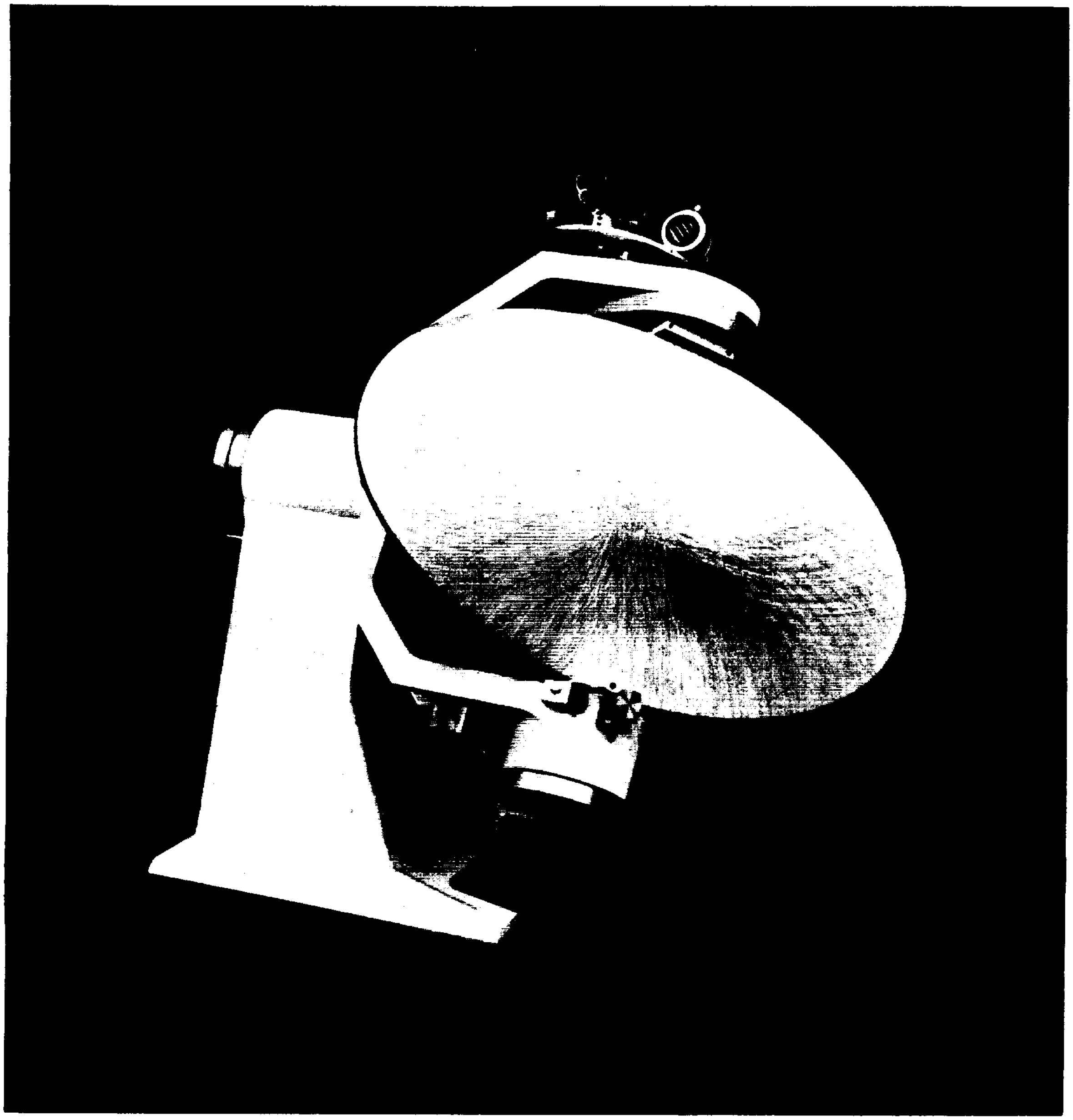
The Ames Research Center has three two-axis line-of-sight image stabilizers that may be used by experimenters (Figs. 10.1, 10.2). The instrument consists basically of a two-axis gimbal with a cast aluminum Kanogen-coated mirror rigidly attached to the inner axis and the associated electronics.

The oval mirror (13 x 22.5 inches, Fig. 10.2) is optically flat to 1/4 wave per inch. The unit may be mounted on a variety of instrument platforms and was designed to reflect the line of sight from athwartship in either a fore or aft direction longitudinally along the airplane. It is the experimenter's responsibility to design his instrument platform to accommodate the image stabilizer.

The mirror is rotated by dc torque motors which are controlled by two gyroscopes that sense aircraft motions. One gyroscope senses motion about the roll axis (outer gimbal), and the second gyroscope detects components of motion about both the pitch and the yaw axes (inner gimbal). The uncorrected components of yaw and pitch result in a rotation of the image about the line of sight (usually ±1/4° or less); this effect may be noticeable at the outer edge of a photograph. The linear stability of the line of sight is better than ±10 arcseconds rms for periods of 180 seconds or more, and approximately ±0.5 arcseconds rms for periods of a few seconds. These values were found to hold even in "light" turbulence. To compensate for the double-angle reflection of the mirror, the inner gimbal is driven at 1/2 the speed of the outer gimbal.

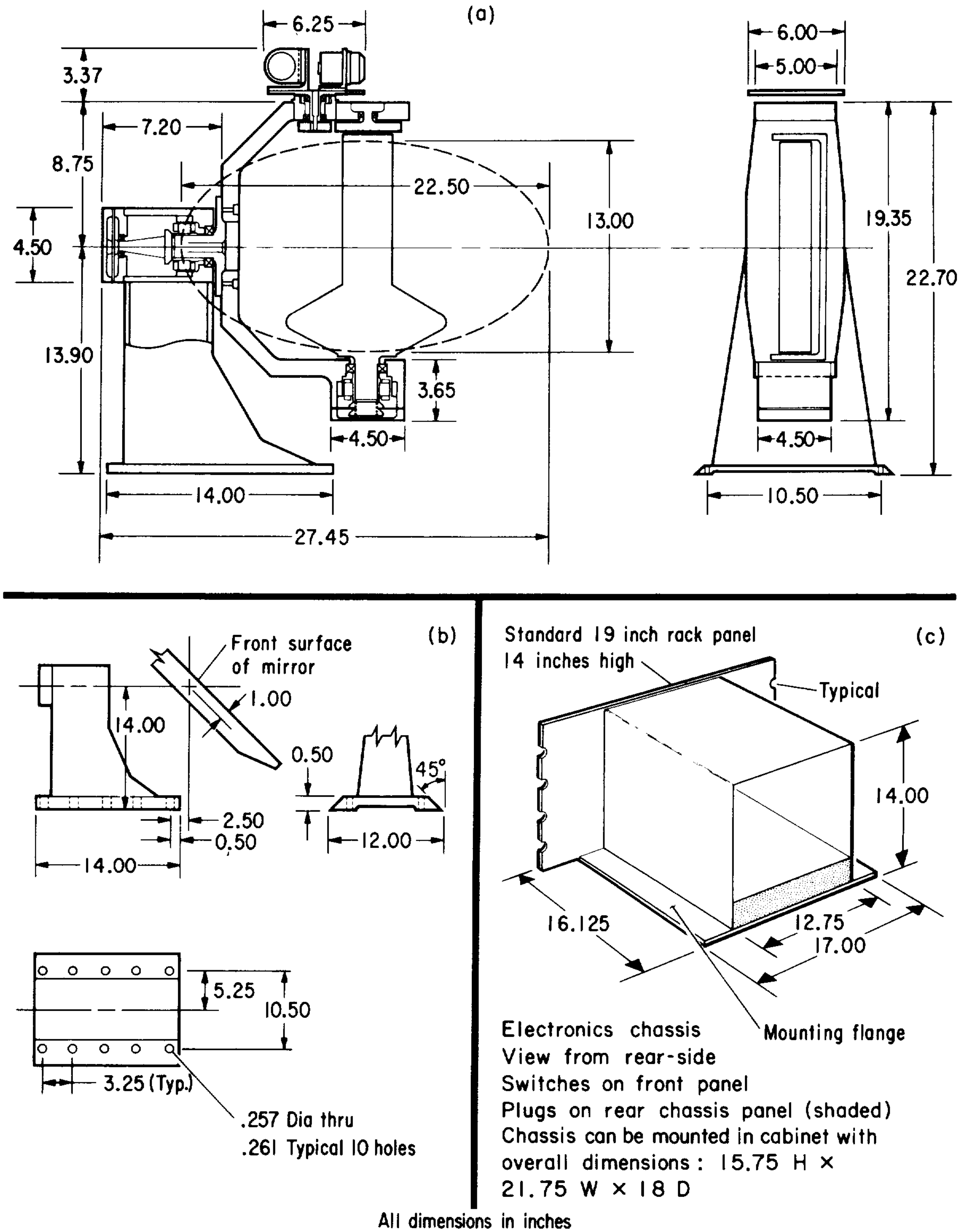
The mirror may be electrically slewed 360° about the outer axis and ±20° about the inner axis through the use of a small control paddle. This paddle contains a two-axis control stick which provides slew rates proportional to stick displacements. With the gyroscopes in the "uncaged" mode, the operator may override the gyroscopes to compensate for slow random drifts. The paddle also contains adjustments to trim for minimum inertial drift.

Each gyro-controlled image stabilizer requires 4.2 amperes (peak) at 400 Hz, 115 V. The necessary cables and connectors are provided by the Ames Research Center. The gimballed mirror weighs 81 pounds, and the associated electronics console weighs 63 pounds.



General view of gyrostabilized mirror.

Figure 10.1 (Nov. 70)



Dimensions of gyrostabilized mirror system.

Figure 10.2 (Nov. 70)